FLOW FIELD ANALYSIS OF SOME MIXING AND CONVEYING SCREW ELEMENT REGIONS, WITHIN A CLOSELY INTERMESHING, CO-ROTATING TWIN-SCREW EXTRUDER

VOLUME 2

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Appendix A: Example of a Mesh Data File (.mdf).

```
01.02.000 ** MESH GENERATOR *MECANIQUE APPLIQUEE* / MESH   DATA   FILE /
**
*** No User's Comment ***
  4
* LEVEL 1 : Description of the Macro-Vertices
  6
    0.0000000     0.0000000     0.0000000
    0.0057362     0.0000000     0.0000000
    0.0082350     0.0048900     0.0000000
    0.0000000     0.0048900     0.0000000
   -0.0082350     0.0048900     0.0000000
   -0.0057362     0.0000000     0.0000000
* LEVEL 2 : Geometrical Description of the Macro-Segments
  7
  1   2   1   0
  2   3   1   0
  3   4   1   0
  1   4   1   0
  4   5   1   0
  5   6   1   0
  1   6   1   0
* LEVEL 2 : Description of the Macro-Elements
  2
  4
  1   2   3   4
  4
  4   5   6   1
 * LEVEL 3 : Generation specifications
  1   1   0
  1   1   0
 * LEVEL 3 : Distribution specifications
  1   2  20    F   3   1
    3.0000000
  2   3  20    F   3   1
    1.0000000
  3   4  20    F   3   1
    2.0000000
  1   4  20    F   3   1
    1.0000000
  4   5  20    F   3   1
    3.0000000
  5   6  20    F   3   1
    1.0000000
  1   6  20    F   3   1
    3.0000000
 * LEVEL 4 : Output format for the boundaries
  1
  1
  1
 * LEVEL 4 : Renumbering data
  0
 * LEVEL 4 : Subdomains
  2
  1   2
 * LEVEL 4 : Boundary sets data
  2
  3   0   5   0   2   1
  5   0   3   0   2   1
 * LEVEL 4 : Pmeshes
    0
* LEVEL 4 : Definition of Additional Fields
  0
```

Appendix B: Example of a Mesh File (.msh) - Reduced.

```
BEGIN ROOT MESH
    2  800  861    0 1660    2    2
    2    0    1   -4

.........................................................................

.........................................................................

1660    0  800   -5
1657    0  800   -5
    1    3    8    6    9   16   12   14   17   26
   20   22   24   27   38   30   32   34   36   39

.........................................................................

.........................................................................

 1621 1623 1625 1627 1629 1631 1633 1635 1637 1639
 1641 1643 1645 1647 1649 1651 1653 1655 1657 1659
    3    3    3    3    3    3    3    3    3    3
    3    3    3    3    3    3    3    3    3    3

.........................................................................

.........................................................................

    2    2    2    2    2    2    2    2    2    2
    2    2    2    2    2    2    2    2    2    2
    1    2
    2    3

.........................................................................

.........................................................................

  859  861
  861  860
ENDOF ROOT MESH
BEGIN PMESH
    0    2
ENDOF PMESH
BEGIN REORDER
  191  172  154  137  121  106   92   79   67   56
   46   37   29   22   16   11    7    4    2    1
  211  192  173  155  138  122  107   93   80   68
   57   47   38   30   23   17   12    8    5    3

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.........................................................................

  800  799  797  794  790  785  779  772  764  755
  745  734  722  709  695  680  664  647  629  610
ENDOF REORDER
BEGIN FIELD
COORDINATES               1    1    1    2 1722
-0.8209614E-02-0.8235000E-02-0.8219617E-02-0.8194280E-02-0.8173849E-02
```

-0.8148653E-02-0.8133614E-02-0.8118421E-02-0.8098823E-02-0.8073858E-02

....

....

0.2664890E-03 0.0000000E+00 0.3010196E-04 0.1196668E-03 0.0000000E+00
0.3010196E-04 0.0000000E+00
ENDOF FIELD

Appendix C: Example of a Data File (.dat).

```
#           P O L Y D A T A
#            - 3 . 4 . 6 -
#                  1
#
BEGIN PA3MN          1
#Main menu
.   1   0
#
  BEGIN BAKEN          1
#  Save and exit
  .   1   0
  ENDOF BAKEN
#
  BEGIN RDMSH          1
#  Read a mesh file
  .   0   0
  ENDOF RDMSH
#
  BEGIN RDOPT          1
#  Read and optimize a mesh file
  .   1   0
  ENDOF RDOPT
#
  BEGIN CVMSH          1
#  Convert a mesh file
  .   1   0
  ENDOF CVMSH
#
  BEGIN SYNTA          1
#  Filename syntax
  .   1   1
  I  1|   1
  ENDOF SYNTA
#
  BEGIN OUTPU          1
#  Outputs
  .   1   2
  I  1|  32
  I  1|   2
  D  3| 0.1000000E+01 0.1000000E+01 0.1000000E-01
  ENDOF OUTPU
#
  BEGIN RDDAT          1
#  Read an old data file
  .   0   0
  ENDOF RDDAT
#
  BEGIN CRRUN          1
#  Create a new task
  .   1   0
  I  1|   1
  ENDOF CRRUN
#
  BEGIN MDRUN          1
#  Redefine global parameters of a task
  .   0   0
  ENDOF MDRUN
#
```

```
  BEGIN NRUN1          1
#  F.E.M. Task 1
  .   1   1
  C 79|F.E.M. Task  1
      |
  I  1|   1
  I  1|   0
  I  1|   0
  C 79|New computation
      |
  I  1|   6
  D  1| 0.1000000E-08
  D  1| 0.1000000E+05
  I  1|   4
  L  1|   F
  D  3| 0.0000000E+00 0.0000000E+00 0.0000000E+00
#
    BEGIN NUPAR          1
#    Numerical parameters
    .   1   5
    I  1|  50
    D  2| 0.1000000E-07 0.1000000E+05
    I  1|   0
    I  1|   0
    I  1|   0
    I  0|
    D  6| 0.0000000E+00 0.1000000E+01 0.1000000E-01 0.1000000E-03
        | 0.2500000E+00 0.1000000E-02
    I  1|  20
    I  1|   0
    C 80|
        |
    C 80|
        |
    D  3| 0.0000000E+00 0.1000000E+01 0.1000000E-03
    D  1| 0.0000000E+00
    L  1|   T
    L  1|   T
    L  1|   F
    ENDOF NUPAR
#
    BEGIN CRPRO          1
#    Create a sub-task
    .   1   0
    ENDOF CRPRO
#
    BEGIN MDPRO          1
#    Redefine global parameters of a sub-task
    .   0   0
    ENDOF MDPRO
#
    BEGIN ASSVE          1
#    Velocity fields management
    .   0   0
    C 79|2.
        |
    I  2| 764   0
    ENDOF ASSVE
#
    BEGIN ASSTP          1
#    Temperature fields management
    .   0   0
    ENDOF ASSTP
#
```

MAX Nº OF ITERATIONS

CONVERGENCE CRITERIA

DIVERGENCE CRITERIA

```
      BEGIN ASSPR          1
#      Pressure fields management
      .    0    0
      C 79|2.
          |
      I  2| 764    0
      ENDOF ASSPR
#
      BEGIN ASSST          1
#      Stresses fields management
      .    0    0
      ENDOF ASSST
#
      BEGIN ASSDA          1
#      Darcy fields management
      .    0    0
      ENDOF ASSDA
#
      BEGIN ASSMS          1
#      Species fields management
      .    0    0
      ENDOF ASSMS
#
      BEGIN ASSPT          1
#      Potential fields management
      .    0    0
      ENDOF ASSPT
#
      BEGIN ASSHF          1
#      Thickness fields management
      .    0    0
      ENDOF ASSHF
#
      BEGIN ASSIN          1
#      Interfaces management (UV)
      .    0    0
      ENDOF ASSIN
#
      BEGIN PRCDN          1
#      Assign the pressure
      .    1    0
      C 79|2.
          |
      D  3| 0.0000000E+00 0.0000000E+00 0.0000000E+00
      I  1|    1
      D  1| 0.1000000E+06
      C 79|
          |
      ENDOF PRCDN
#
      BEGIN PSICN          1
#      Assign the stream function
      .    0    0
      ENDOF PSICN
#
      BEGIN CMINT          1
#      Mesh-mesh interpolation
      .    0    0
      ENDOF CMINT
#
      BEGIN ESPES          1
#      Define species
      .    0    0
      ENDOF ESPES
#
      BEGIN REACT          1
#      Define reactions
      .    0    0
      ENDOF REACT
#
```

AT THE POINT

PRESSURE ASSIGNED

```
    BEGIN PRBLM          1
#    Task 1 Sub-task 1
    .   1   3
    C 79|3D Rotation
        |
    I  1|    1
    I  1|    0
    I  1|   -1
    I  1|    0
    I  1|   -1
    I  1|   -1
    I  1|   -1
    I  1|   -1
    I  1|   -1
    I  1|   -1
    I  1|   -1
#
      BEGIN SUPOR         1
#      Domain of the sub-task
      .   1   0
      I  1|   2
      C 79|2.
          |
      I  1|   0
      ENDOF SUPOR
#
      BEGIN MATDA         1
#      Material data
      .   1   0
#
        BEGIN VISGA         1
#        Shear-rate dependence of viscosity
        .   1   0
        I  1|   3
#
          BEGIN CSTGA         1
#          Constant viscosity
          .   1   0
          D  1| 0.1000000E+01
          D  1| 0.0000000E+00
          D  1| 0.0000000E+00
          D  1| 0.0000000E+00
          D  1| 0.0000000E+00
          C 79|          f(g) = fac
              |
          ENDOF CSTGA
#
          BEGIN BIRCA         1
#          Bird-Carreau law
          .   1   0
          D  1| 0.1000000E+01
          D  1| 0.0000000E+00
          D  1| 0.1000000E+01
          D  1| 0.0000000E+00
          D  1| 0.0000000E+00
          C 79|        f(g) = facinf + (fac-facinf) *
              |
          C 79|                 ( 1 + tnat*tnat*g*g)**((expo-1)/2)
              |
          ENDOF BIRCA
#
```

```
          BEGIN RELAX          1
#          Relaxation mode
           .   1   0
          C 79|Relaxation mode  1
               |
          I  1|    1
          D  1| 0.1000000E+01
          D  1| 0.1000000E+01
          ENDOF RELAX
        ENDOF VINTG
#
        BEGIN MASPE          1
#        Density
        .   1   0
        D  1| 0.8000000E+03
        ENDOF MASPE \
#
        BEGIN INERT          1
#        Inertia terms
        .   1   0
        L  1|    F
        ENDOF INERT
#
        BEGIN VOLEX          1
#        Coefficient of thermal expansion
        .   1   0
        D  1| 0.0000000E+00
        D  1| 0.0000000E+00
        C 79| The density will be given by :   ro*( 1 - beta*( t - tb
            |eta) )
        C 79|
            |
        C 79|     where  - ro is the reference density introduced in
            |the 'density' menu
        C 79|            - beta is the coefficient of thermal expansi
            |on
        C 79|            - tbeta is a reference temperature
            |
        ENDOF VOLEX
#
        BEGIN CONDU          1
#        Thermal conductivity
        .   1   0
        D  1| 0.1000000E+01
        D  1| 0.0000000E+00
        D  1| 0.0000000E+00
        D  1| 0.0000000E+00
        C 79|      condu = a + b*t + c*t*t + d*t*t*t
            |
        ENDOF CONDU
#
        BEGIN HECAP          1
#        Heat capacity per unit mass
        .   1   0
        D  1| 0.0000000E+00
        D  1| 0.0000000E+00
        D  1| 0.0000000E+00
        D  1| 0.0000000E+00
        C 79|         Cp = a + b*t + c*t**2 + d*t**3
            |
        ENDOF HECAP
#
        BEGIN CONVE          1
#        Heat convection
        .   1   0
        L  1|    F
        ENDOF CONVE
#
```

DENSITY ASSIGNED

```
         BEGIN VHEAT        1
#         Viscous heating
         .    1   0
         L   1|    F
         ENDOF VHEAT
#
         BEGIN GRAVI        1
#         Gravity
         .    1   0
         D   1| 0.0000000E+00
         D   1|-0.9810000E+01
         D   1| 0.0000000E+00
         ENDOF GRAVI
#
         BEGIN TINIT        1
#         Average estimate
         .    1   1
         C 79|Average temperature
              |
         D   1| 0.3000000E+03
         ENDOF TINIT
#
         BEGIN PRODQ        1
#         Source per unit volume
         .    1   1
         C 79|Heat source per unit volume
              |
         D   1| 0.0000000E+00
         ENDOF PRODQ
#
         BEGIN ADVCO        1
#         Carrier fluid concentration
         .    1   0
         D   1| 0.1013250E+06
         D   1| 0.8314300E+01
         C 79|Ideal gas law : c(T) = Po / Rg * T
              |
         ENDOF ADVCO
#
         BEGIN ADVDF        1
#         Diffusivity
         .    1   1
         D   1| 0.1000000E+01
         D   1| 0.0000000E+00
         C 79|Power law : D(T) = fact * (T)**expo
              |
         I   1|    0
         D   1| 0.1000000E+01
         D   1| 0.0000000E+00
         D   1| 0.0000000E+00
         D   1| 0.0000000E+00
         ENDOF ADVDF
#
         BEGIN ADVAT        1
#         Thermal diffusion factor
         .    1   0
         D   1| 0.0000000E+00
         D   1| 0.0000000E+00
         D   1| 0.0000000E+00
         C 79|Polynomial law : a(T) = a0 + a1 *T + a2 *T*T
              |
         ENDOF ADVAT
#
         BEGIN SIGTY        1
#         Electrical conductivity
         .    1   0
         I   1|    1
#
```

```
            BEGIN CSTSG          1
#            Constant conductivity
            .   1   0
            D  1| 0.1000000E+01
            D  1| 0.0000000E+00
            D  1| 0.0000000E+00
            C 79|           sig(T) = a
                |
            ENDOF CSTSG
#
            BEGIN LINSG          1
#            Linear conductivity
            .   1   0
            D  1| 0.1000000E+01
            D  1| 0.0000000E+00
            D  1| 0.0000000E+00
            C 79|           sig(T) = a + b * T
                |
            ENDOF LINSG
#
            BEGIN EXPSG          1
#            Exponential conductivity
            .   1   0
            D  1| 0.1000000E+01
            D  1| 0.0000000E+00
            D  1| 0.0000000E+00
            C 79|           sig(T) = a * exp ( b - c/T )
                |
            ENDOF EXPSG
          ENDOF SIGTY
        ENDOF MATDA
#
        BEGIN BDCVE          1
#        Flow boundary conditions
        .   1   0
        L  1|   T
        D  1| 0.1000000E+01
#
          BEGIN BDSVE          1
#          Flow Boundary Set
          .   1   2
          C 79|Inflow along boundary  1
              |
          I  1|   3
          I  1|   7
          C 79|(2*3).
              |
          D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
              | 0.0000000E+00
          I  5|  -1  -1   1   0   0
          I  3|   0  -1  -1
          D  5|-0.5200000E-06 0.0000000E+00 0.0000000E+00 0.0000000E+00
              | 0.0000000E+00
          I  3|   0  -1  -1
          D  5|-0.5200000E-06 0.0000000E+00 0.0000000E+00 0.0000000E+00
              | 0.0000000E+00
          I  3|  -1  -1  -1
          D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
              | 0.0000000E+00
          I  1|   0
          ENDOF BDSVE
#
```

```
        BEGIN BDSVE          2
#        Flow Boundary Set
        .   1    2
        C 79|vx,vy,vz imposed along boundary  2
            |
        I  1|    4
        I  1|   11
        C 79|(2*4).
            |
        D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        I  5|  -1  -1  -1  -1  -1
        I  3|   1  -1  -1
        D  5|-0.1750500E-01 0.0000000E+00-0.1000000E-01-0.6283185E+01
            | 0.0000000E+00
        I  3|   1  -1  -1
        D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        I  3|   1  -1  -1
        D  5|-0.1750500E-01 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        I  1|    0
        ENDOF BDSVE
#
        BEGIN BDSVE          3
#        Flow Boundary Set
        .   1    2
        C 79|vx,vy,vz imposed along boundary  3
            |
        I  1|    5
        I  1|   11
        C 79|(2*5).
            |
        D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        I  5|  -1  -1  -1  -1  -1
        I  3|   1  -1  -1
        D  5| 0.1750500E-01 0.0000000E+00-0.1000000E-01-0.6283185E+01
            | 0.0000000E+00
        I  3|   1  -1  -1
        D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        I  3|   1  -1  -1
        D  5| 0.1750500E-01 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        I  1|    0
        ENDOF BDSVE
#
        BEGIN BDSVE          4
#        Flow Boundary Set
        .   1    2
        C 79|vn & vs imposed along boundary  4
            |
        I  1|    6
        I  1|    1
        C 79|(2*6).
            |
        D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        I  5|  -1  -1  -1  -1  -1
        I  3|   0  -1  -1
        D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        I  3|   0  -1  -1
        D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        I  3|   0  -1  -1
        D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        I  1|    0
```

```
          ENDOF BDSVE
#
          BEGIN BDSVE        5
#          Flow Boundary Set
          .   1   2
          C 79|Outflow along boundary  5
              |
          I  1|   7
          I  1|   8
          C 79|(2*7).
              |
          D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
              | 0.0000000E+00
          I  5|   3  -1  -1  -1   0
          I  3|   0  -1  -1
          D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
              | 0.2000000E+01
          I  3|   0  -1  -1
          D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
              | 0.2000000E+01
          I  3|  -1  -1  -1
          D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
              | 0.0000000E+00
          I  1|   0
          ENDOF BDSVE
        ENDOF BDCVE
#
        BEGIN BDCPR         1
#        Pressure boundary conditions
        .   0   0
        ENDOF BDCPR
#
        BEGIN BDCTP         1
#        Thermal boundary conditions
        .   0   1
        I  1|   1
        C 79|
            |
        I  1|  -1
        D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        ENDOF BDCTP
#
        BEGIN BDCMS         1
#        Concentration boundary conditions
        .   0   0
        ENDOF BDCMS
#
        BEGIN BDCPT         1
#        Potential boundary conditions
        .   0   0
        ENDOF BDCPT
#
        BEGIN BDCHF         1
#        Thickness boundary conditions
        .   0   0
        ENDOF BDCHF
#
        BEGIN SMAIL         1
#        Global remeshing
        .   0   0
        ENDOF SMAIL
#
```

```
      BEGIN RIGTR          1
#      Rigid translation
      .   1   0
      I  1|   0
      C 79|.
          |
      I  1|  -1
      D  1| 0.0000000E+00
      D  1| 0.0000000E+00
      D  1| 0.0000000E+00
      C 79|Translation speed : d/dt (X, Y, Z) = (Ux, Uy, Uz)
          |
      ENDOF RIGTR
#
      BEGIN INTRP          1
#      Interpolation
      .   1   0
      I  1|   1
      I  1|   0
      L  1|   F
      I  2|   3   0
      L  1|   F
      ENDOF INTRP
#
      BEGIN BUBBL          1
#      Bubbling
      .   1   0
      I  1|   0
      ENDOF BUBBL
    ENDOF PRBLM
#
    BEGIN PRBLM          2
#    Task 1 Sub-task 1
    .   1   3
    C 79|Local shear-rate
        |
    I  1|   5
    I  1|   1
    I  1| 764
    I  1|   0
    I  1|  -1
    I  1|  -1
    I  1|  -1
    I  1|  -1
    I  1|  -1
    I  1|  -1
    I  1|  -1
#
      BEGIN SUPOR          1
#      Domain of the sub-task
      .   1   0
      I  1|   2
      C 79|2.
          |
      I  1|   0
      ENDOF SUPOR
#
      BEGIN MATDA          1
#      Material data
      .   0   0
      ENDOF MATDA
#
      BEGIN BDCPR          1
#      Pressure boundary conditions
      .   0   0
      ENDOF BDCPR
#
```

```
      BEGIN BDCMS          1
#      Concentration boundary conditions
      .   0   0
      ENDOF BDCMS
#
      BEGIN BDCPT          1
#      Potential boundary conditions
      .   0   0
      ENDOF BDCPT
#
      BEGIN BDCHF          1
#      Thickness boundary conditions
      .   0   0
      ENDOF BDCHF
#
      BEGIN RIGTR          1
#      Rigid translation
      .   1   0
      I  1|   0
      C 79|.
          |
      I  1|  -1
      D  1| 0.0000000E+00
      D  1| 0.0000000E+00
      D  1| 0.0000000E+00
      C 79|Translation speed : d/dt (X, Y, Z) = (Ux, Uy, Uz)
          |
      ENDOF RIGTR
    ENDOF PRBLM
#
    BEGIN PRBLM          3
#    Task 1 Sub-task 1
    .   1   3
    C 79|Inelastic stress tensor
        |
    I  1|   5
    I  1|   4
    I  1| 764
    I  1|   0
    I  1|  -1
    I  1|  -1
    I  1|  -1
    I  1|  -1
    I  1|  -1
    I  1|  -1
    I  1|  -1
#
      BEGIN SUPOR          1
#      Domain of the sub-task
      .   1   0
      I  1|   2
      C 79|2.
          |
      I  1|   0
      ENDOF SUPOR
#
      BEGIN MATDA          1
#      Material data
      .   0   0
      ENDOF MATDA
#
      BEGIN BDCPR          1
#      Pressure boundary conditions
      .   0   0
      ENDOF BDCPR
#
      BEGIN BDCMS          1
#      Concentration boundary conditions
      .   0   0
      ENDOF BDCMS
```

```
#
        BEGIN BDCPT          1
#        Potential boundary conditions
        .   0   0
        ENDOF BDCPT
#
        BEGIN BDCHF          1
#        Thickness boundary conditions
        .   0   0
        ENDOF BDCHF
#
        BEGIN RIGTR          1
#        Rigid translation
        .   1   0
        I  1|   0
        C 79|.
            |
        I  1|  -1
        D  1| 0.0000000E+00
        D  1| 0.0000000E+00
        D  1| 0.0000000E+00
        C 79|Translation speed : d/dt (X, Y, Z) = (Ux, Uy, Uz)
            |
        ENDOF RIGTR
      ENDOF PRBLM
#
      BEGIN PRBLM          4
#      Task 1 Sub-task 1
      .   1   3
      C 79|Mixing efficiency
          |
      I  1|   5
      I  1|   1
      I  1| 764
      I  1|   0
      I  1|  -1
      I  1|  -1
      I  1|  -1
      I  1|  -1
      I  1|  -1
      I  1|  -1
      I  1|  -1
#
        BEGIN SUPOR          1
#        Domain of the sub-task
        .   1   0
        I  1|   2
        C 79|2.
            |
        I  1|   0
        ENDOF SUPOR
#
        BEGIN MATDA          1
#        Material data
        .   0   0
        ENDOF MATDA
#
        BEGIN BDCPR          1
#        Pressure boundary conditions
        .   0   0
        ENDOF BDCPR
#
        BEGIN BDCMS          1
#        Concentration boundary conditions
        .   0   0
        ENDOF BDCMS
#
```

```
        BEGIN BDCPT         1
#        Potential boundary conditions
        .   0   0
        ENDOF BDCPT
#
        BEGIN BDCHF         1
#        Thickness boundary conditions
        .   0   0
        ENDOF BDCHF
#
        BEGIN RIGTR         1
#        Rigid translation
        .   1   0
        I  1|   0
        C 79|.
            |
        I  1|  -1
        D  1| 0.0000000E+00
        D  1| 0.0000000E+00
        D  1| 0.0000000E+00
        C 79|Translation speed : d/dt (X, Y, Z) = (Ux, Uy, Uz)
            |
        ENDOF RIGTR
      ENDOF PRBLM
    ENDOF NRUN1
ENDOF PA3MN
#
```

```
BEGIN OPEN         1
#Files opening
.   0   0
C 55|MSH__1 f i       md3d0x1.msh
C 55|RES__1 f o       60m2nsa.res
C 55|CFV__1 f o       60m2nsa.cfv
#
  BEGIN TOPO         1
#  Topological operations
  .   0   0
  C  6|MSH__1
  C 35|   1  root mesh                    1
  C 55|1.
  C 35|   1 S1.                           2
  C 55|2.
  C 35|   1 (S1*B1).                      3
  C 55|(2*3).
  C 35|   1 (S1*B2).                      4
  C 55|(2*4).
  C 35|   1 (S1*B3).                      5
  C 55|(2*5).
  C 35|   1 (S1*B4).                      6
  C 55|(2*6).
  C 35|   1 (S1*B5).                      7
  C 55|(2*7).
#
    BEGIN FIELDS       1
#    Fields definition
    .   0   0
#
      BEGIN FIELD1       1
#      One field definition
      .   1   0
      I  5|   1   1   1   3   0
      C 21|XY   COORDINATES
#
        BEGIN READ         1
#        One field initialization by read
        .   0   0
        C  6|MSH__1
        ENDOF READ
      ENDOF FIELD1
#
      BEGIN FIELD1       2
#      One field definition
      .   1   0
      I  5|   2   3   1   3   0
      C 21|UV   VELOCITIES
      ENDOF FIELD1
#
      BEGIN FIELD1       3
#      One field definition
      .   1   0
      I  5|   2   1   0   1  -1
      C 21|P    PRESSURE
      ENDOF FIELD1
#
      BEGIN FIELD1       4
#      One field definition
      .   1   0
      I  5|   3   5   0   1   0
      C 21|Q     Flow rate
#
```

```
          BEGIN EVALX          1
#           One field initialization by interpolatio
          .    0    0
          L   1|    F
          I   2|    3    1
          I   1|    4
          D   1|-0.5200000E-06
          ENDOF EVALX
        ENDOF FIELD1
#
        BEGIN FIELD1         5
#         One field definition
        .    1    0
        I   5|    3    3    1    3    0
        C  21|v ns Veloc. N/S
        ENDOF FIELD1
#
        BEGIN FIELD1         6
#         One field definition
        .    1    0
        I   5|    3    5    0    1    0
        C  21|Gr.p Grad P
        ENDOF FIELD1
#
        BEGIN FIELD1         7
#         One field definition
        .    1    0
        I   5|    3    1    0    1    0
        C  21|p    Pressure
        ENDOF FIELD1
#
        BEGIN FIELD1         8
#         One field definition
        .    1    0
        I   5|    7    3    1    3    0
        C  21|v ns Veloc. N/S
        ENDOF FIELD1
#
        BEGIN FIELD1         9
#         One field definition
        .    1    0
        I   5|    7    1    0    1    0
        C  21|p    Pressure
        ENDOF FIELD1
#
        BEGIN FIELD1        10
#         One field definition
        .    1    0
        I   5|    2    3    0    1    0
        C  21|GMP  LOCAL SHEAR-RATE
        ENDOF FIELD1
#
        BEGIN FIELD1        11
#         One field definition
        .    1    0
        I   5|    2    1    2    6    0
        C  21|T    TENSOR T
        ENDOF FIELD1
#
        BEGIN FIELD1        12
#         One field definition
        .    1    0
        I   5|    2    3    0    1    0
        C  21|MIX  LOCAL MIXING
        ENDOF FIELD1
#
```

```
         BEGIN FIELD1       13
#         One field definition
         .   1   0
         I  5|   2   5   0   1   0
         C 21|GMP  LOCAL SHEAR-RATE
         ENDOF FIELD1
#
         BEGIN FIELD1       14
#         One field definition
         .   1   0
         I  5|   2   5   2   6   0
         C 21|T    TENSOR T
         ENDOF FIELD1
#
         BEGIN FIELD1       15
#         One field definition
         .   1   0
         I  5|   2   5   0   1   0
         C 21|MIX  LOCAL MIXING
         ENDOF FIELD1
#
         BEGIN FIELD1       16
#         One field definition
         .   1   0
         I  5|   7   5   0   1   0
         C 21|Qo   Q-output
         ENDOF FIELD1
#
         BEGIN PROBLS        1
#         Problems definition
         .   0   0
#
           BEGIN BEVXYZ        1
#           Condition on a field at given coord.
           .   1   0
           C 16| P = 0
           I  3|   3   2   1
           D  3| 0.0000000E+00 0.0000000E+00 0.0000000E+00
           I  1|   1
           D  1| 0.1000000E+06
           ENDOF BEVXYZ
#
           BEGIN PROB1         1
#           One problem specifications
           .   1   1
           C 16|Navier-Stokes 3D
           I  4|   1   1   2   1
           I  1|   1
           I  2|   2   3
           I  2|   0   0
           L 11|   F   F   F   F   T   F   F   F   F   F   F
           I  3|   3   1   5
           D 28| 0.8000000E+03 0.0000000E+00 0.0000000E+00 0.0000000E+00
               | 0.0000000E+00 0.4400000E+04 0.0000000E+00 0.5000000E+00
               | 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
               | 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
               | 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
               | 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
               | 0.0000000E+00 0.0000000E+00-0.9810000E+01 0.0000000E+00
           ENDOF PROB1
#
```

```
        BEGIN PROB1         2
#        One problem specifications
        .   1   0
        C 16| Inflow
        I  3|  54   1   3
        I  2|   1   4
        I  2|   2   6
        I  2|   0   2
        L  1|   F
        I  2|   5   0
        D  0|
        ENDOF PROB1
#
        BEGIN BEVAXS        1
#        Field init.(parameter) on a boundary
        .   1   0
        C 16| Vs = 0
        I  3|   5   3   2
        I  1|   1
        I  4|   1   0   0   0
        D  0|
        D  0|
        D  0|
        I  4|   2   0   0   0
        D  0|
        D  0|
        D  0|
        ENDOF BEVAXS
#
        BEGIN BEVAXS        2
#        Field init.(parameter) on a boundary
        .   1   0
        C 16|Vx Vy Vz imposed
        I  3|   2   4   0
        I  1|   1
        I  4|   1   7   0   0
        D  5| 0.0000000E+00 0.0000000E+00-0.6283185E+01 0.0000000E+00
            | 0.0000000E+00
        D  0|
        D  0|
        I  4|   2   7   0   0
        D  5| 0.1099872E+00 0.6283185E+01 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        D  0|
        D  0|
        I  4|   3   7   0   0
        D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        D  0|
        D  0|
        ENDOF BEVAXS
#
```

```
        BEGIN BEVAXS          3
#        Field init.(parameter) on a boundary
        .    1    0
        C 16|Vx Vy Vz imposed
        I  3|    2    5    0
        I  1|    1
        I  4|    1    7    0    0
        D  5| 0.0000000E+00 0.0000000E+00-0.6283185E+01 0.0000000E+00
            | 0.0000000E+00
        D  0|
        D  0|
        I  4|    2    7    0    0
        D  5|-0.1099872E+00 0.6283185E+01 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        D  0|
        D  0|
        I  4|    3    7    0    0
        D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        D  0|
        D  0|
        ENDOF BEVAXS
#
        BEGIN BEVAXS          4
#        Field init.(parameter) on a boundary
        .    1    0
        C 16| Vn Vs imposed
        I  3|    2    6    0
        I  1|    1
        I  4|    1    0    0    0
        D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        D  0|
        D  0|
        I  4|    2    0    0    0
        D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        D  0|
        D  0|
        I  4|    3    0    0    0
        D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00
        D  0|
        D  0|
        ENDOF BEVAXS
#
        BEGIN BEVAXS          5
#        Field init.(parameter) on a boundary
        .    1    0
        C 16| Outflow  Vs = 0
        I  3|    8    7    2
        I  1|    1
        I  4|    1    0    0    0
        D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.2000000E+01
        D  0|
        D  0|
        I  4|    2    0    0    0
        D  5| 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.2000000E+01
        D  0|
        D  0|
        ENDOF BEVAXS
#
```

```
#          BEGIN PROB1          3
            One problem specifications
           .    1    0
           C 16| Outflow
           I  3| 109    1    7
           I  1|   1
           I  2|   8    3
           I  2|   0    0
           L  1|   F
           I  2|   5    0
           D  0|
#
             BEGIN BEVAXS          1
#             Field init.(parameter) on a boundary
             .    1    0
             C 16| Liaison Vns Vxy
             I  3|   8    7    2
             I  1|   1
             ENDOF BEVAXS
#
             BEGIN BEVXYZ          1
#             Condition on a field at given coord.
             .    1    0
             C 16| Zero pressure
             I  3|   3    7    1
             D  3| 0.0000000E+00 0.0000000E+00 0.0000000E+00
             I  1|   1
             D  1| 0.0000000E+00
             ENDOF BEVXYZ
#
             BEGIN BEVXYZ          2
#             Condition on a field at given coord.
             .    1    0
             C 16| P = 0
             I  3|   9    7    1
             D  3| 0.0000000E+00 0.0000000E+00 0.0000000E+00
             I  1|   1
             D  1| 0.0000000E+00
             ENDOF BEVXYZ
           ENDOF PROB1
#
           BEGIN PROB1          4
#           One problem specifications
           .    1    0
           C 16|Calcul. of IId
           I  3|  19    1    2
           I  2|   1    2
           I  1|  10
           I  1|   0
           L  4|   F    T    F    F
           I  5|   1    3    1    5    0
           D 14| 0.4400000E+04 0.0000000E+00 0.5000000E+00 0.0000000E+00
               | 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
               | 0.0000000E+00 0.0000000E+00 0.1000000E+01 0.0000000E+00
               | 0.0000000E+00 0.0000000E+00
           ENDOF PROB1
#
```

```
        BEGIN PROB1          5
#        One problem specifications
        .   1   0
        C 16|Tensor T
        I  3|  19   1   2
        I  2|   1   2
        I  1|  11
        I  1|   0
        L  4|   F   T   F   F
        I  5|   4   3   1   5   0
        D 14| 0.4400000E+04 0.0000000E+00 0.5000000E+00 0.0000000E+00
            | 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00 0.0000000E+00 0.1000000E+01 0.0000000E+00
            | 0.0000000E+00 0.0000000E+00
        ENDOF PROB1
#
        BEGIN PROB1          6
#        One problem specifications
        .   1   0
        C 16|Calcul. of mixing
        I  3|  19   1   2
        I  2|   1   2
        I  1|  12
        I  1|   0
        L  4|   F   T   F   F
        I  5|  19   3   1   5   0
        D 14| 0.4400000E+04 0.0000000E+00 0.5000000E+00 0.0000000E+00
            | 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00 0.0000000E+00 0.1000000E+01 0.0000000E+00
            | 0.0000000E+00 0.0000000E+00
        ENDOF PROB1
#
        BEGIN PROB1          7
#        One problem specifications
        .   1   0
        C 16|Calcul. of IId
        I  3|  19   1   2
        I  2|   1   2
        I  1|  13
        I  1|   0
        L  4|   F   T   F   F
        I  5|   1   3   1   5   0
        D 14| 0.4400000E+04 0.0000000E+00 0.5000000E+00 0.0000000E+00
            | 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00 0.0000000E+00 0.1000000E+01 0.0000000E+00
            | 0.0000000E+00 0.0000000E+00
        ENDOF PROB1
#
        BEGIN PROB1          8
#        One problem specifications
        .   1   0
        C 16|Tensor T
        I  3|  19   1   2
        I  2|   1   2
        I  1|  14
        I  1|   0
        L  4|   F   T   F   F
        I  5|   4   3   1   5   0
        D 14| 0.4400000E+04 0.0000000E+00 0.5000000E+00 0.0000000E+00
            | 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
            | 0.0000000E+00 0.0000000E+00 0.1000000E+01 0.0000000E+00
            | 0.0000000E+00 0.0000000E+00
        ENDOF PROB1
#
```

```
       BEGIN PROB1          9
#       One problem specifications
       .   1   0
       C 16|Calcul. of mixing
       I  3|  19   1   2
       I  2|   1   2
       I  1|  15
       I  1|   0
       L  4|   F   T   F   F
       I  5|  19   3   1   5   0
       D 14| 0.4400000E+04 0.0000000E+00 0.5000000E+00 0.0000000E+00
           | 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
           | 0.0000000E+00 0.0000000E+00 0.1000000E+01 0.0000000E+00
           | 0.0000000E+00 0.0000000E+00
       ENDOF PROB1
#
       BEGIN PROB1         10
#       One problem specifications
       .   1   1
       C 16|Post-Processor 2D
       I  4|  18   1   7   2
       I  2|   1   2
       I  1|  16
       I  1|   0
       L  6|   F   T   F   F   F   F
       I  6|   8   1   1   5   0   0
       D 20| 0.4400000E+04 0.0000000E+00 0.5000000E+00 0.0000000E+00
           | 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
           | 0.0000000E+00 0.0000000E+00 0.1000000E+01 0.0000000E+00
           | 0.0000000E+00 0.0000000E+00 0.1000000E+01 0.1000000E+01
           | 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
       ENDOF PROB1
#
       BEGIN EVOLU          1
#       Multi-step problem definition
       .   1   0
       C   6|RES__1
#
         BEGIN SOLVER        1
#         Solver
         .   1   0
         C 16|F.E.M. Task  1
         I  3|  50   1   0
         L  4|   T   T   T   T
         D  2| 0.1000000E-07 0.1000000E+05
         I  3|   1   2   3
         ENDOF SOLVER
#
         BEGIN SOLVER        2
#         Solver
         .   1   0
         C 16| Postprocessors
         I  3|   6   3   0
         L  4|   T   T   F   T
         D  2| 0.1000000E-07 0.1000000E+05
         I  1|   4
         ENDOF SOLVER
#
         BEGIN SOLVER        3
#         Solver
         .   1   0
         C 16| Postprocessors
         I  3|   6   3   0
         L  4|   T   T   F   T
         D  2| 0.1000000E-07 0.1000000E+05
         I  1|   5
         ENDOF SOLVER
#
```

```
          BEGIN SOLVER        4
#          Solver
          .   1   0
          C 16| Postprocessors
          I  3|    6   3   0
          L  4|    T   T   F   T
          D  2| 0.1000000E-07 0.1000000E+05
          I  1|    6
          ENDOF SOLVER
#
          BEGIN SOLVER        5
#          Solver
          .   1   0
          C 16| Postprocessors
          I  3|    6   3   0
          L  4|    T   T   F   T
          D  2| 0.1000000E-07 0.1000000E+05
          I  1|    7
          ENDOF SOLVER
#
          BEGIN SOLVER        6
#          Solver
          .   1   0
          C 16| Postprocessors
          I  3|    6   3   0
          L  4|    T   T   F   T
          D  2| 0.1000000E-07 0.1000000E+05
          I  1|    8
          ENDOF SOLVER
#
          BEGIN SOLVER        7
#          Solver
          .   1   0
          C 16| Postprocessors
          I  3|    6   3   0
          L  4|    T   T   F   T
          D  2| 0.1000000E-07 0.1000000E+05
          I  1|    9
          ENDOF SOLVER
#
          BEGIN SOLVER        8
#          Solver
          .   1   0
          C 16| Postprocessors
          I  3|    6   3   0
          L  4|    T   T   F   T
          D  2| 0.1000000E-07 0.1000000E+05
          I  1|   10
          ENDOF SOLVER
#
          BEGIN OUTPUT        1
#          Output
          .   0   0
#
            BEGIN CFVPF         1
#            Interface CFView-PF
            .   0   0
            C   6|CFV__1
            I 10|    2    2    3   10   11   12   13   14   15   16
            I  3|    3    8    0
            I  3|    4    8    0
            I  3|    5    8    0
            I  3|    6    8    0
            I  3|    7    8    0
            ENDOF CFVPF
          ENDOF OUTPUT
        ENDOF EVOLU
      ENDOF PROBLS
    ENDOF FIELDS
  ENDOF TOPO
```

```
#
  BEGIN VERBOS         1
#  Control of verbosity
  .   0   0
  C 12|BANNER      2
  C 12|GPS         0
  C 12|ADR         0
  C 12|TOPO        2
  C 12|FIELDS      2
  C 12|PROBLEMS    2
  C 12|B.CONDIT.   2
  C 12|CONSTRAINT 0
  C 12|SOLVER      2
  ENDOF VERBOS
ENDOF OPEN
```

Appendix D: Example of a Listings File (.lst).

```
Startup file is /disk2/user/ceacsg1/brucedp/.p3rc
PPPPPP   OOOOO  LL    YY     YY      FFFFFFF LL       OOOOO  WW     WW
PP    PP OO    OO LL   YY     YY     FF        LL     OO     OO WW     WW
PP    PP OO    OO LL   YY     YY    FF        LL     OO     OO WW     WW
PPPPPP   OO    OO LL    YY   YY   FFFFF    LL     OO     OO WW     WW
PP       OO    OO LL     YYYY    FF       LL     OO     OO WW  W  WW
PP       OO    OO LL      YY    FF       LL     OO     OO WW  W  WW
PP       OO    OO LL      YY   FF       LL     OO     OO WWW    WWW
PP        OOOOO  LLLLLLL YY FF      LLLLLLL OOOOO  WW      WW


***************************************************************
*                                                             *
*                         POLYFLOW s.a.                       *
```

```
*************************
*                       *
*  Version  3. 4. 6     *
*           1           *
*                       *
*************************


*************************
*                       *
*         TOPO          *
*                       *
*************************

 root mesh
                  Space Dim.     :           3
                  Num. of bricks:         2298
                  Num. of faces :         8125
                  Num. of segm. :         9508
                  Num. of nodes :         3680

S1.
                  Space Dim.     :           3
                  Num. of bricks:         2298
                  Num. of faces :         8125
                  Num. of segm. :         9508
                  Num. of nodes :         3680
```

(S1*B1).

Space Dim.	:	2
Num. of faces	:	766
Num. of segm.	:	1687
Num. of nodes	:	920

(S1*B2).

Space Dim.	:	2
Num. of faces	:	405
Num. of segm.	:	945
Num. of nodes	:	540

(S1*B3).

Space Dim.	:	2
Num. of faces	:	135
Num. of segm.	:	315
Num. of nodes	:	180

(S1*B4).

Space Dim.	:	2
Num. of faces	:	390
Num. of segm.	:	910
Num. of nodes	:	520

(S1*B5).

Space Dim.	:	2
Num. of faces	:	766
Num. of segm.	:	1687
Num. of nodes	:	920

```
************************
*                      *
*       FIELDS         *
*                      *
************************
```

COORDINATES

Abreviated as	:	XY
Support	:	root mesh
Interp. Type	:	P1;C0
Tensor Type	:	1
Num. of Comp.	:	3
Num. of Var.	:	11040

VELOCITIES

Abreviated as	:	UV
Support	:	S1.
Interp. Type	:	P2;C0
Tensor Type	:	1
Num. of Comp.	:	3
Num. of Var.	:	70833

PRESSURE

Abreviated as	:	P
Support	:	S1.
Interp. Type	:	P1;C0
Tensor Type	:	0
Num. of Comp.	:	1
Num. of Var.	:	3680

Flow rate

Abreviated as	:	Q
Support	:	(S1*B1).
Interp. Type	:	Cste over domain
Tensor Type	:	0
Num. of Comp.	:	1
Num. of Var.	:	1

Veloc. N/S

Abreviated as	:	v ns
Support	:	(S1*B1).
Interp. Type	:	P2;C0
Tensor Type	:	1
Num. of Comp.	:	3
Num. of Var.	:	10119

Grad P

Abreviated as	:	Gr.p
Support	:	(S1*B1).
Interp. Type	:	Cste over domain
Tensor Type	:	0
Num. of Comp.	:	1
Num. of Var.	:	1

Pressure

Abreviated as	:	p
Support	:	(S1*B1).
Interp. Type	:	P1;C0
Tensor Type	:	0
Num. of Comp.	:	1
Num. of Var.	:	920

Veloc. N/S

Abreviated as	:	v ns
Support	:	(S1*B5).
Interp. Type	:	P2;C0
Tensor Type	:	1
Num. of Comp.	:	3
Num. of Var.	:	10119

Pressure

Abreviated as	:	p
Support	:	(S1*B5).
Interp. Type	:	P1;C0
Tensor Type	:	0
Num. of Comp.	:	1
Num. of Var.	:	920

LOCAL SHEAR

Abreviated as	:	GMP
Support	:	S1.
Interp. Type	:	P2;C0
Tensor Type	:	0
Num. of Comp.	:	1
Num. of Var.	:	23611

TENSOR T

Abreviated as	:	T
Support	:	S1.
Interp. Type	:	P1;C0
Tensor Type	:	2
Num. of Comp.	:	6
Num. of Var.	:	22080

```
LOCAL MIXIN
                    Abreviated as :                MIX
                    Support       :                S1.
                    Interp. Type  :              P2;C0
                    Tensor  Type  :                  0
                    Num. of Comp. :                  1
                    Num. of Var.  :              23611


LOCAL SHEAR
                    Abreviated as :                GMP
                    Support       :                S1.
                    Interp. Type  : Cste over domain
                    Tensor  Type  :                  0
                    Num. of Comp. :                  1
                    Num. of Var.  :                  1


TENSOR T
                    Abreviated as :                  T
                    Support       :                S1.
                    Interp. Type  : Cste over domain
                    Tensor  Type  :                  2
                    Num. of Comp. :                  6
                    Num. of Var.  :                  6


LOCAL MIXIN
                    Abreviated as :                MIX
                    Support       :                S1.
                    Interp. Type  : Cste over domain
                    Tensor  Type  :                  0
                    Num. of Comp. :                  1
                    Num. of Var.  :                  1


Q-output
                    Abreviated as :                 Qo
                    Support       :           (S1*B5).
                    Interp. Type  : Cste over domain
                    Tensor  Type  :                  0
                    Num. of Comp. :                  1
                    Num. of Var.  :                  1



*************************
*                       *
*       PROBLEMS        *
*                       *
*************************


Navier-Stokes 3D
                    Support       :                S1.
                    Coordinates   :        COORDINATES
                    Input Fields  :        -
                    Output Fields :         VELOCITIES
                                              PRESSURE

       Navier-Stokes 3D
       isothermal flow problem
       generalized newtonian fluid

       no streamline upwinding in momentum equation
       picard iteration for viscosity law
```

```
viscosity function : visc = F(g)

shear-rate dependence of the viscosity   : F(g)
  viscosity law : power law :
  F(g) = fac * g**(expo-1)
    fac     =  4.40000E+03 ,expo    =  5.00000E-01

specific mass : ro        =  8.00000E+02

gravity field taken into account :
    gx      =  0.00000E+00
    gy      = -9.81000E+00
    gz      =  0.00000E+00

inertia terms neglected in momentum equation


Inflow
                Support        :        (S1*B1).
                Coordinates    :     COORDINATES
                Input Fields   :       Flow rate
                Output Fields  :      VELOCITIES
                                          Grad P

NORMAL FORCE AND FLOW RATE
==========================

 imposed on a 2D cross-section (the domain is 3D)


Outflow
                Support        :        (S1*B5).
                Coordinates    :     COORDINATES
                Input Fields   :        -
                Output Fields  :      Veloc. N/S
                                        PRESSURE


Calcul. of IId
                Support        :             S1.
                Coordinates    :     COORDINATES
                Input Fields   :      VELOCITIES
                Output Fields  :     LOCAL SHEAR

algebraic post-processor 3D
the mean least square technique is applied for computing
the local shear rate 'gamma-dot'


Tensor T
                Support        :             S1.
                Coordinates    :     COORDINATES
                Input Fields   :      VELOCITIES
                Output Fields  :        TENSOR T

algebraic post-processor 3D
the mean least square technique is applied for computing
the stress tensor T

viscosity function : visc = F(g)

shear-rate dependence of the viscosity   : F(g)
  viscosity law : power law :
  F(g) = fac * g**(expo-1)
    fac     =  4.40000E+03 ,expo    =  5.00000E-01
```

```
Calcul. of mixin
                    Support          :            S1.
                    Coordinates      :    COORDINATES
                    Input Fields     :     VELOCITIES
                    Output Fields    :    LOCAL MIXIN

       algebraic post-processor 3D
       the mean least square technique is applied for computing
       the function d/(d+w)


Calcul. of IId
                    Support          :            S1.
                    Coordinates      :    COORDINATES
                    Input Fields     :     VELOCITIES
                    Output Fields    :    LOCAL SHEAR

       algebraic post-processor 3D
       the mean least square technique is applied for computing
       the local shear rate 'gamma-dot'


Tensor T
                    Support          :            S1.
                    Coordinates      :    COORDINATES
                    Input Fields     :     VELOCITIES
                    Output Fields    :       TENSOR T

       algebraic post-processor 3D
       the mean least square technique is applied for computing
       the stress tensor T

       viscosity function : visc = F(g)

       shear-rate dependence of the viscosity  : F(g)
         viscosity law : power law :
         F(g) = fac * g**(expo-1)
           fac     =   4.40000E+03 ,expo    =   5.00000E-01


Calcul. of mixin
                    Support          :            S1.
                    Coordinates      :    COORDINATES
                    Input Fields     :     VELOCITIES
                    Output Fields    :    LOCAL MIXIN

       algebraic post-processor 3D
       the mean least square technique is applied for computing
       the function d/(d+w)


Post-Processor 2
                    Support          :       (S1*B5).
                    Coordinates      :    COORDINATES
                    Input Fields     :     VELOCITIES
                    Output Fields    :       Q-output

       algebraic post-processor 2D and 2D 1/2
       the flow rate through the current boundary part is obtained
       from the integration of the velocity field

       plane geometry
```

```
*************************
*                       *
*  Boundary Conditions  *
*                       *
*************************
```

```
 Liaison Vns Vxy
                  Field           :     Veloc. N/S
                  Support         :       (S1*B5).
                  Lagr. Mult. of:       VELOCITIES
                  Act. on Probs :
                                           Outflow


 Vs = 0
                  Field           :     Veloc. N/S
                  Support         :       (S1*B1).
                  Lagr. Mult. of:       VELOCITIES
                  Act. on Probs :
                                  Navier-Stokes 3D
                                            Inflow
                                           Outflow
                                    Calcul. of IId
                                          Tensor T
                                  Calcul. of mixin
                                    Calcul. of IId
                                          Tensor T
                                  Calcul. of mixin
                                  Post-Processor 2
                  For comp. 1     :     Zero Value
                  For comp. 2     :     Zero Value


Vx Vy Vz imposed
                  Field           :     VELOCITIES
                  Support         :       (S1*B2).
                  Act. on Probs :
                                  Navier-Stokes 3D
                                            Inflow
                                           Outflow
                                    Calcul. of IId
                                          Tensor T
                                  Calcul. of mixin
                                    Calcul. of IId
                                          Tensor T
                                  Calcul. of mixin
                                  Post-Processor 2
                  For comp. 1     :  Funct.  7 used
                  For comp. 2     :  Funct.  7 used
                  For comp. 3     :  Funct.  7 used


Vx Vy Vz imposed
                  Field           :     VELOCITIES
                  Support         :       (S1*B3).
                  Act. on Probs :
                                  Navier-Stokes 3D
                                            Inflow
                                           Outflow
                                    Calcul. of IId
                                          Tensor T
                                  Calcul. of mixin
                                    Calcul. of IId
                                          Tensor T
                                  Calcul. of mixin
                                  Post-Processor 2
                  For comp. 1     :  Funct.  7 used
                  For comp. 2     :  Funct.  7 used
                  For comp. 3     :  Funct.  7 used
```

```
Vn Vs imposed
                    Field           :      VELOCITIES
                    Support         :       (S1*B4).
                    Act. on Probs   :
                                     Navier-Stokes 3D
                                               Inflow
                                              Outflow
                                       Calcul. of IId
                                             Tensor T
                                     Calcul. of mixin
                                       Calcul. of IId
                                             Tensor T
                                     Calcul. of mixin
                                     Post-Processor 2
                    For comp. 1     :      Zero Value
                    For comp. 2     :      Zero Value
                    For comp. 3     :      Zero Value


Outflow   Vs = 0
                    Field           :      Veloc. N/S
                    Support         :       (S1*B5).
                    Lagr. Mult. of:        VELOCITIES
                    Act. on Probs   :
                                     Navier-Stokes 3D
                                               Inflow
                                              Outflow
                                       Calcul. of IId
                                             Tensor T
                                     Calcul. of mixin
                                       Calcul. of IId
                                             Tensor T
                                     Calcul. of mixin
                                     Post-Processor 2
                    For comp. 1     :      Zero Value
                    For comp. 2     :      Zero Value


*************************
*                       *
*        SOLVER         *
*                       *
*************************


F.E.M. Task  1
                    Type of Evolu.:          Implicit
                    Infl. on Evol.:          Influent
                    Explicit part :          One pass
                    Problem list    :
                                     Navier-Stokes 3D
                                               Inflow
                                              Outflow

                    Nitmax          :              50
                    Static          :               T
                    Conver. Crit. :     0.1000000E-07
                    Diverg. Crit. :     0.1000000E+05
                    Print Iter.     :               T


Frontal method preprocessor
Maximum frontal width :   1294
Number of active var. :  43578
Number of static var. :   6902
BLAS3 in use, Blocs =          20
```

```
Iteration    1

Frontal method information :
 Minimal pivot          :  0.1937432E-16
 Maximal pivot          :  0.5730315E+03
 log10 / sign (det.)    :  0.7111102E+04 /  1
 Maximal rhs            : -0.2287599E+02
 Relative var. of field  VELOCITIES         0.1000000E+01
 Relative var. of field (PRESSURE           0.1000000E+01)
 Relative var. of field  Veloc. N/S         0.1000000E+01
 Relative var. of field  Grad P             0.1000000E+01
 Relative var. of field  Veloc. N/S         0.1000000E+01

Iteration    2

Frontal method information :
 Minimal pivot          :  0.1402268E-15
 Maximal pivot          :  0.1971791E+03
 log10 / sign (det.)    : -0.2337855E+05 /  1
 Maximal rhs            : -0.8585958E+00
 Relative var. of field  VELOCITIES         0.8730840E-01
 Relative var. of field (PRESSURE           0.3018232E+02)
 Relative var. of field  Veloc. N/S         0.1261249E+00
 Relative var. of field  Grad P             0.3234326E+01
 Relative var. of field  Veloc. N/S         0.1324824E+00

Iteration    3

Frontal method information :
 Minimal pivot          :  0.1231819E-15
 Maximal pivot          :  0.3114774E+03
 log10 / sign (det.)    : -0.2042417E+05 /  1
 Maximal rhs            :  0.8476212E-02
 Relative var. of field  VELOCITIES         0.3146219E-01
 Relative var. of field (PRESSURE           0.1210261E+00)
 Relative var. of field  Veloc. N/S         0.3343865E-01
 Relative var. of field  Grad P             0.1461724E+00
 Relative var. of field  Veloc. N/S         0.3845588E-01

Iteration    4

Frontal method information :
 Minimal pivot          :  0.1175142E-15
 Maximal pivot          :  0.4152498E+03
 log10 / sign (det.)    : -0.1913705E+05 /  1
 Maximal rhs            : -0.2997244E-02
 Relative var. of field  VELOCITIES         0.1485865E-01
 Relative var. of field (PRESSURE           0.4651829E-01)
 Relative var. of field  Veloc. N/S         0.1191951E-01
 Relative var. of field  Grad P             0.6462103E-01
 Relative var. of field  Veloc. N/S         0.1493558E-01

Iteration    5

Frontal method information :
 Minimal pivot          :  0.1156776E-15
 Maximal pivot          :  0.4901114E+03
 log10 / sign (det.)    : -0.1857672E+05 /  1
 Maximal rhs            :  0.1228125E-02
 Relative var. of field  VELOCITIES         0.6678801E-02
 Relative var. of field (PRESSURE           0.1574646E-01)
 Relative var. of field  Veloc. N/S         0.4667895E-02
 Relative var. of field  Grad P             0.2777761E-01
 Relative var. of field  Veloc. N/S         0.6033448E-02
```

```
Iteration     6

Frontal method information :
 Minimal pivot          :  0.1150658E-15
 Maximal pivot          :  0.5293811E+03
 log10 / sign (det.)    : -0.1833230E+05 /  1
 Maximal rhs            :  0.5229650E-03
 Relative var. of field  VELOCITIES          0.3093346E-02
 Relative var. of field (PRESSURE            0.5292592E-02)
 Relative var. of field  Veloc. N/S          0.1885893E-02
 Relative var. of field  Grad P              0.1194244E-01
 Relative var. of field  Veloc. N/S          0.2523623E-02


Iteration     7

Frontal method information :
 Minimal pivot          :  0.1148592E-15
 Maximal pivot          :  0.5482987E+03
 log10 / sign (det.)    : -0.1822540E+05 /  1
 Maximal rhs            :  0.2291658E-03
 Relative var. of field  VELOCITIES          0.1420354E-02
 Relative var. of field (PRESSURE            0.1779557E-02)
 Relative var. of field  Veloc. N/S          0.7890774E-03
 Relative var. of field  Grad P              0.5158959E-02
 Relative var. of field  Veloc. N/S          0.1069919E-02


Iteration     8

Frontal method information :
 Minimal pivot          :  0.1147907E-15
 Maximal pivot          :  0.5570591E+03
 log10 / sign (det.)    : -0.1817855E+05 /  1
 Maximal rhs            :  0.1027320E-03
 Relative var. of field  VELOCITIES          0.6484647E-03
 Relative var. of field (PRESSURE            0.5902024E-03)
 Relative var. of field  Veloc. N/S          0.3509173E-03
 Relative var. of field  Grad P              0.2238819E-02
 Relative var. of field  Veloc. N/S          0.4552118E-03


Iteration     9

Frontal method information :
 Minimal pivot          :  0.1147692E-15
 Maximal pivot          :  0.5610489E+03
 log10 / sign (det.)    : -0.1815797E+05 /  1
 Maximal rhs            :  0.4689256E-04
 Relative var. of field  VELOCITIES          0.2951212E-03
 Relative var. of field (PRESSURE            0.1940028E-03)
 Relative var. of field  Veloc. N/S          0.1579539E-03
 Relative var. of field  Grad P              0.9750244E-03
 Relative var. of field  Veloc. N/S          0.1943532E-03


Iteration    10

Frontal method information :
 Minimal pivot          :  0.1147631E-15
 Maximal pivot          :  0.5628544E+03
 log10 / sign (det.)    : -0.1814893E+05 /  1
 Maximal rhs            :  0.2171256E-04
 Relative var. of field  VELOCITIES          0.1340761E-03
 Relative var. of field (PRESSURE            0.6284608E-04)
 Relative var. of field  Veloc. N/S          0.7176226E-04
 Relative var. of field  Grad P              0.4257013E-03
 Relative var. of field  Veloc. N/S          0.8328251E-04
```

```
Iteration    11

Frontal method information :
 Minimal pivot          :  0.1147618E-15
 Maximal pivot          :  0.5636695E+03
 log10 / sign (det.)    : -0.1814495E+05 /  1
 Maximal rhs            :  0.1016634E-04
 Relative var. of field  VELOCITIES          0.6085764E-04
 Relative var. of field (PRESSURE            0.2477883E-04)
 Relative var. of field  Veloc. N/S          0.3255921E-04
 Relative var. of field  Grad P              0.1861722E-03
 Relative var. of field  Veloc. N/S          0.3582353E-04


Iteration    12

Frontal method information :
 Minimal pivot          :  0.1147618E-15
 Maximal pivot          :  0.5640373E+03
 log10 / sign (det.)    : -0.1814320E+05 /  1
 Maximal rhs            :  0.4801094E-05
 Relative var. of field  VELOCITIES          0.2761507E-04
 Relative var. of field (PRESSURE            0.1127937E-04)
 Relative var. of field  Veloc. N/S          0.1476166E-04
 Relative var. of field  Grad P              0.8150137E-04
 Relative var. of field  Veloc. N/S          0.1546963E-04


Iteration    13

Frontal method information :
 Minimal pivot          :  0.1147620E-15
 Maximal pivot          :  0.5642031E+03
 log10 / sign (det.)    : -0.1814243E+05 /  1
 Maximal rhs            :  0.2282139E-05
 Relative var. of field  VELOCITIES          0.1253181E-04
 Relative var. of field (PRESSURE            0.5166288E-05)
 Relative var. of field  Veloc. N/S          0.6690892E-05
 Relative var. of field  Grad P              0.3569691E-04
 Relative var. of field  Veloc. N/S          0.6759466E-05


Iteration    14

Frontal method information :
 Minimal pivot          :  0.1147621E-15
 Maximal pivot          :  0.5642779E+03
 log10 / sign (det.)    : -0.1814209E+05 /  1
 Maximal rhs            :  0.1090097E-05
 Relative var. of field  VELOCITIES          0.5720336E-05
 Relative var. of field (PRESSURE            0.2378481E-05)
 Relative var. of field  Veloc. N/S          0.3032959E-05
 Relative var. of field  Grad P              0.1563610E-04
 Relative var. of field  Veloc. N/S          0.2979849E-05


Iteration    15

Frontal method information :
 Minimal pivot          :  0.1147622E-15
 Maximal pivot          :  0.5643116E+03
 log10 / sign (det.)    : -0.1814195E+05 /  1
 Maximal rhs            :  0.5226075E-06
 Relative var. of field  VELOCITIES          0.2651451E-05
 Relative var. of field (PRESSURE            0.1099797E-05)
 Relative var. of field  Veloc. N/S          0.1375267E-05
 Relative var. of field  Grad P              0.6847319E-05
 Relative var. of field  Veloc. N/S          0.1356313E-05
```

```
Iteration    16

Frontal method information :
 Minimal pivot          :  0.1147623E-15
 Maximal pivot          :  0.5643267E+03
 log10 / sign (det.)    : -0.1814188E+05 /   1
 Maximal rhs            :  0.2512350E-06
 Relative var. of field  VELOCITIES          0.1228857E-05
 Relative var. of field (PRESSURE            0.5104619E-06)
 Relative var. of field  Veloc. N/S          0.6239012E-06
 Relative var. of field  Grad P              0.2996944E-05
 Relative var. of field  Veloc. N/S          0.6174339E-06


Iteration    17

Frontal method information :
 Minimal pivot          :  0.1147623E-15
 Maximal pivot          :  0.5643336E+03
 log10 / sign (det.)    : -0.1814185E+05 /   1
 Maximal rhs            :  0.1210263E-06
 Relative var. of field  VELOCITIES          0.5695608E-06
 Relative var. of field (PRESSURE            0.2377133E-06)
 Relative var. of field  Veloc. N/S          0.2832053E-06
 Relative var. of field  Grad P              0.1310671E-05
 Relative var. of field  Veloc. N/S          0.2811630E-06


Iteration    18

Frontal method information :
 Minimal pivot          :  0.1147624E-15
 Maximal pivot          :  0.5643366E+03
 log10 / sign (det.)    : -0.1814184E+05 /   1
 Maximal rhs            :  0.5860899E-07
 Relative var. of field  VELOCITIES          0.2640284E-06
 Relative var. of field (PRESSURE            0.1110259E-06)
 Relative var. of field  Veloc. N/S          0.1286393E-06
 Relative var. of field  Grad P              0.5725975E-06
 Relative var. of field  Veloc. N/S          0.1280893E-06


Iteration    19

Frontal method information :
 Minimal pivot          :  0.1147624E-15
 Maximal pivot          :  0.5643380E+03
 log10 / sign (det.)    : -0.1814183E+05 /   1
 Maximal rhs            :  0.2843196E-07
 Relative var. of field  VELOCITIES          0.1224744E-06
 Relative var. of field (PRESSURE            0.5199331E-07)
 Relative var. of field  Veloc. N/S          0.5847279E-07
 Relative var. of field  Grad P              0.2498372E-06
 Relative var. of field  Veloc. N/S          0.5838371E-07


Iteration    20

Frontal method information :
 Minimal pivot          :  0.1147624E-15
 Maximal pivot          :  0.5643386E+03
 log10 / sign (det.)    : -0.1814183E+05 /   1
 Maximal rhs            :  0.1380081E-07
 Relative var. of field  VELOCITIES          0.5695619E-07
 Relative var. of field (PRESSURE            0.2440706E-07)
 Relative var. of field  Veloc. N/S          0.2659816E-07
 Relative var. of field  Grad P              0.1088414E-06
 Relative var. of field  Veloc. N/S          0.2662659E-07
```

```
Iteration    21

Frontal method information :
 Minimal pivot          :  0.1147624E-15
 Maximal pivot          :  0.5643389E+03
 log10 / sign (det.)    : -0.1814183E+05 /  1
 Maximal rhs            :  0.6702082E-08
 Relative var. of field  VELOCITIES        0.2677814E-07
 Relative var. of field (PRESSURE          0.1148256E-07)
 Relative var. of field  Veloc. N/S        0.1210800E-07
 Relative var. of field  Grad P            0.4733188E-07
 Relative var. of field  Veloc. N/S        0.1215071E-07


Iteration    22

Frontal method information :
 Minimal pivot          :  0.1147624E-15
 Maximal pivot          :  0.5643390E+03
 log10 / sign (det.)    : -0.1814183E+05 /  1
 Maximal rhs            :  0.3256048E-08
 Relative var. of field  VELOCITIES        0.1272219E-07
 Relative var. of field (PRESSURE          0.5413042E-08)
 Relative var. of field  Veloc. N/S        0.5515915E-08
 Relative var. of field  Grad P            0.2054055E-07
 Relative var. of field  Veloc. N/S        0.5548271E-08


Iteration    23

Frontal method information :
 Minimal pivot          :  0.1147624E-15
 Maximal pivot          :  0.5643391E+03
 log10 / sign (det.)    : -0.1814183E+05 /  1
 Maximal rhs            :  0.1582442E-08
 Relative var. of field  VELOCITIES        0.6051773E-08
 Relative var. of field (PRESSURE          0.2556569E-08)
 Relative var. of field  Veloc. N/S        0.2514685E-08
 Relative var. of field  Grad P            0.8892462E-08
 Relative var. of field  Veloc. N/S        0.2535068E-08
Convergence assumed : Rel. var. LT  0.1000000E-07


*************************
*                       *
*        SOLVER         *
*                       *
*************************


 Postprocessors
                  Type of Evolu.:        Explicit
                  Infl. on Evol.:     Transparent
                  Explicit part :        One pass
                  Problem list  :
                                    Calcul. of IId

                  Nitmax        :               6
                  Static        :               T
                  Conver. Crit. :    0.1000000E-07
                  Diverg. Crit. :    0.1000000E+05
                  Print Iter.   :               T
```

```
Frontal method preprocessor
Maximum frontal width :    482
Number of active var. :  18191
Number of static var. :   5420
BLAS3 in use, Blocs =          20


Iteration    1

Frontal method information :
 Minimal pivot          :  0.1983149E-13
 Maximal pivot          :  0.5316473E-09
 log10 / sign (det.)    : -0.2495639E+06 /  1
 Maximal rhs            :  0.1287985E-06
 Relative var. of field  LOCAL SHEAR      0.1000000E+01


Iteration    2

Frontal method information :
 Minimal pivot          :  0.1983149E-13
 Maximal pivot          :  0.5316473E-09
 log10 / sign (det.)    : -0.2495639E+06 /  1
 Maximal rhs            :  0.9264423E-22
 Relative var. of field  LOCAL SHEAR      0.2844649E-14
Convergence assumed : Rel. var. LT  0.1000000E-07



************************
*                      *
*       SOLVER         *
*                      *
************************



 Postprocessors
                 Type of Evolu.:        Explicit
                 Infl. on Evol.:     Transparent
                 Explicit part :        One pass
                 Problem list  :
                                        Tensor T

                 Nitmax        :               6
                 Static        :               T
                 Conver. Crit. :   0.1000000E-07
                 Diverg. Crit. :   0.1000000E+05
                 Print Iter.   :               T


Frontal method preprocessor
Maximum frontal width :    798
Number of active var. :  21984
Number of static var. :     96
BLAS3 in use, Blocs =          20


Iteration    1

Frontal method information :
 Minimal pivot          :  0.6197360E-12
 Maximal pivot          :  0.7367612E-09
 log10 / sign (det.)    : -0.2195902E+06 /  1
 Maximal rhs            : -0.7358483E-04
 Relative var. of field  TENSOR T         0.1000000E+01
```

```
Iteration     2

Frontal method information :
 Minimal pivot          :  0.6197360E-12
 Maximal pivot          :  0.7367612E-09
 log10 / sign (det.)    : -0.2195902E+06 /  1
 Maximal rhs            :  0.3875176E-19
 Relative var. of field  TENSOR T          0.2858581E-14
Convergence assumed : Rel. var. LT  0.1000000E-07



************************
*                      *
*       SOLVER         *
*                      *
************************



 Postprocessors
                 Type of Evolu.:        Explicit
                 Infl. on Evol.:     Transparent
                 Explicit part :        One pass
                 Problem list  :
                                Calcul. of mixin

                 Nitmax        :               6
                 Static        :               T
                 Conver. Crit. :   0.1000000E-07
                 Diverg. Crit. :   0.1000000E+05
                 Print Iter.   :               T


Frontal method preprocessor
Maximum frontal width :    482
Number of active var. :  18191
Number of static var. :   5420
BLAS3 in use, Blocs =          20


Iteration     1

Frontal method information :
 Minimal pivot          :  0.1983149E-13
 Maximal pivot          :  0.5316473E-09
 log10 / sign (det.)    : -0.2495639E+06 /  1
 Maximal rhs            :  0.5525010E-09
 Relative var. of field  LOCAL MIXIN       0.1000000E+01


Iteration     2

Frontal method information :
 Minimal pivot          :  0.1983149E-13
 Maximal pivot          :  0.5316473E-09
 log10 / sign (det.)    : -0.2495639E+06 /  1
 Maximal rhs            :  0.4135903E-24
 Relative var. of field  LOCAL MIXIN       0.3606005E-14
Convergence assumed : Rel. var. LT  0.1000000E-07
```

```
************************
*                      *
*       SOLVER         *
*                      *
************************
```

```
 Postprocessors
                Type of Evolu.:        Explicit
                Infl. on Evol.:     Transparent
                Explicit part :        One pass
                Problem list  :
                                  Calcul. of IId

                Nitmax        :               6
                Static        :               T
                Conver. Crit. :   0.1000000E-07
                Diverg. Crit. :   0.1000000E+05
                Print Iter.   :               T


Frontal method preprocessor
Maximum frontal width :      1
Number of active var. :      1
Number of static var. :      0
BLAS3 in use, Blocs =           20


Iteration    1

Frontal method information :
 Minimal pivot         :  0.2915414E-05
 Maximal pivot         :  0.2915414E-05
 log10 / sign (det.)   : -0.5535300E+01 /  1
 Maximal rhs           :  0.1454083E-03
 Relative var. of field  LOCAL SHEAR      0.1000000E+01


Iteration    2

Frontal method information :
 Minimal pivot         :  0.2915414E-05
 Maximal pivot         :  0.2915414E-05
 log10 / sign (det.)   : -0.5535300E+01 /  1
 Maximal rhs           :  0.2884280E-18
 Relative var. of field  LOCAL SHEAR      0.1994479E-14
Convergence assumed : Rel. var. LT  0.1000000E-07
```

```
*************************
*                       *
*       SOLVER          *
*                       *
*************************


 Postprocessors
                Type of Evolu.:       Explicit
                Infl. on Evol.:    Transparent
                Explicit part :       One pass
                Problem list  :
                                      Tensor T

                Nitmax        :              6
                Static        :              T
                Conver. Crit. :  0.1000000E-07
                Diverg. Crit. :  0.1000000E+05
                Print Iter.   :              T


Frontal method preprocessor
Maximum frontal width :      6
Number of active var. :      6
Number of static var. :      0
BLAS3 in use, Blocs =           20


Iteration    1

Frontal method information :
 Minimal pivot          :  0.2915414E-05
 Maximal pivot          :  0.2915414E-05
 log10 / sign (det.)    : -0.3321180E+02 /  1
 Maximal rhs            :  0.1002990E-02
 Relative var. of field  TENSOR T          0.1000000E+01


Iteration    2

Frontal method information :
 Minimal pivot          :  0.2915414E-05
 Maximal pivot          :  0.2915414E-05
 log10 / sign (det.)    : -0.3321180E+02 /  1
 Maximal rhs            :  0.1101704E-16
 Relative var. of field  TENSOR T          0.1090506E-13
Convergence assumed : Rel. var. LT  0.1000000E-07
```

```
*************************
*                       *
*       SOLVER          *
*                       *
*************************


 Postprocessors
                  Type of Evolu.:        Explicit
                  Infl. on Evol.:     Transparent
                  Explicit part :        One pass
                  Problem list  :
                                  Calcul. of mixin

                  Nitmax        :               6
                  Static        :               T
                  Conver. Crit. :   0.1000000E-07
                  Diverg. Crit. :   0.1000000E+05
                  Print Iter.   :               T


Frontal method preprocessor
Maximum frontal width :      1
Number of active var. :      1
Number of static var. :      0
BLAS3 in use, Blocs =           20


Iteration    1

Frontal method information :
 Minimal pivot          :  0.2915414E-05
 Maximal pivot          :  0.2915414E-05
 log10 / sign (det.)    : -0.5535300E+01 /  1
 Maximal rhs            :  0.1511218E-05
 Relative var. of field  LOCAL MIXIN      0.1000000E+01


Iteration    2

Frontal method information :
 Minimal pivot          :  0.2915414E-05
 Maximal pivot          :  0.2915414E-05
 log10 / sign (det.)    : -0.5535300E+01 /  1
 Maximal rhs            :  0.2057043E-20
 Relative var. of field  LOCAL MIXIN      0.1285093E-14
Convergence assumed : Rel. var. LT  0.1000000E-07
```

```
************************
*                      *
*       SOLVER         *
*                      *
************************


 Postprocessors
                  Type of Evolu.:         Explicit
                  Infl. on Evol.:      Transparent
                  Explicit part :         One pass
                  Problem list  :
                                  Post-Processor 2

                  Nitmax        :                6
                  Static        :                T
                  Conver. Crit. :    0.1000000E-07
                  Diverg. Crit. :    0.1000000E+05
                  Print Iter.   :                T


Frontal method preprocessor
Maximum frontal width :       1
Number of active var. :       1
Number of static var. :       0
BLAS3 in use, Blocs =           20


Iteration    1

Frontal method information :
 Minimal pivot          :  0.1000000E+01
 Maximal pivot          :  0.1000000E+01
 log10 / sign (det.)    : -0.7216450E-14 /   1
 Maximal rhs            :  0.5208735E-06
 Relative var. of field  Q-output         0.0000000E+00
Convergence assumed : Rel. var. LT  0.1000000E-07
```

Appendix E: Example of a Result File (.res) - Reduced.

```
BEGIN FIELD
COORDINATES                1     1     1     3 11040
-0.1265632E-02-0.2480693E-02-0.3666588E-02-0.4549999E-02-0.1585082E-02
-0.2759561E-02-0.3914596E-02-0.4867974E-02-0.1904532E-02-0.2825528E-02

.....................................................................

.....................................................................

-0.3066667E-02-0.3066667E-02-0.3066667E-02-0.3066667E-02-0.4600000E-02
-0.4600000E-02-0.4600000E-02-0.4600000E-02-0.4600000E-02-0.4600000E-02
ENDOF FIELD
BEGIN FIELD
VELOCITIES                 2     3     1     3 70833
 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00

.....................................................................

.....................................................................

-0.4048398E-04-0.3366372E-04-0.3228990E-04-0.3279270E-04-0.3436235E-04
-0.3577225E-04-0.1145980E-03-0.3621998E-04-0.2755416E-04-0.2586612E-04
-0.2692724E-04-0.2843181E-04-0.2941935E-04
ENDOF FIELD
BEGIN FIELD
PRESSURE                   2     1     0     1  3680
 0.6797855E+05 0.4745180E+05 0.3537908E+05 0.1669526E+04-0.7653203E+04
-0.8559998E+04 0.4052335E+04-0.2936573E+05 0.9313728E+04 0.3450544E+04

.....................................................................

.....................................................................

 0.4454767E+03 0.5426433E+03 0.5874439E+03 0.5185047E+03-0.5536294E+03
-0.6496805E+03-0.6252109E+03-0.6248209E+03-0.6073489E+03-0.6039103E+03
ENDOF FIELD
BEGIN FIELD
 Flow rate                 9     5     0     1     1
-0.5200000E-06
ENDOF FIELD
BEGIN FIELD
Veloc. N/S                 9     3     1     3 10119
 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00

.....................................................................

.....................................................................

 0.2140205E-04 0.1757104E-03 0.2125947E-04 0.1766894E-03 0.2132984E-04
 0.1737259E-03 0.2114783E-04 0.1747979E-03 0.2212180E-04 0.4335615E-03
 0.4761724E-03 0.4787018E-03 0.4711786E-03 0.4693669E-03
ENDOF FIELD
BEGIN FIELD
Grad P                     9     5     0     1     1
 0.2932274E+04
ENDOF FIELD
```

```
BEGIN FIELD
Pressure                9     1     0     1   920
 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00

.........................................................................

.........................................................................

 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
ENDOF FIELD
BEGIN FIELD
Veloc. N/S             13     3     1     3 10119
 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00

.........................................................................

.........................................................................

-0.2617711E-04-0.1804767E-03-0.1985772E-04-0.1704456E-03-0.1831495E-04
-0.1753062E-03-0.1947079E-04-0.1789624E-03-0.2068439E-04-0.5839749E-03
-0.4917908E-03-0.4733939E-03-0.4809070E-03-0.4861376E-03
ENDOF FIELD
BEGIN FIELD
Pressure               13     1     0     1   920
 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00

.........................................................................

.........................................................................

 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00 0.0000000E+00
ENDOF FIELD
BEGIN FIELD
LOCAL SHEAR             2     3     0     1 23611
 0.8511253E+02 0.1342007E+03 0.1680791E+03 0.1878259E+03 0.1973596E+03
 0.1705500E+03 0.1644297E+03 0.1647140E+03 0.1486400E+03 0.1474432E+03

.........................................................................

.........................................................................

 0.1135311E+01 0.1127745E+01 0.1115936E+01 0.1111622E+01 0.1477163E+01
 0.6844424E+00 0.5918458E+00 0.5813712E+00 0.5837047E+00 0.5817278E+00
 0.5787311E+00
ENDOF FIELD
BEGIN FIELD
TENSOR T                2     1     2     6 22080
-0.7530872E+04-0.4513127E+03 0.1346680E+05 0.1946903E+05-0.2449779E+04
 0.3367656E+03 0.6274563E+04 0.1731849E+05 0.2416165E+04 0.4784347E+03

.........................................................................

.........................................................................

-0.1071896E+04-0.8615530E+03-0.6772992E+03-0.4444540E+03-0.2127038E+04
-0.1500648E+04-0.1226392E+04-0.1014447E+04-0.8000226E+03-0.5245219E+03
ENDOF FIELD
BEGIN FIELD
LOCAL MIXIN             2     3     0     1 23611
 0.1634983E+00 0.2881566E+00 0.3810606E+00 0.4477062E+00 0.6054454E+00
 0.5810425E+00 0.5163167E+00 0.3734266E+00 0.5888195E+00 0.6276320E+00

.........................................................................

.........................................................................
```

```
 0.5011283E+00 0.5011647E+00 0.5013543E+00 0.5009880E+00 0.4999703E+00
 0.5006388E+00 0.5009496E+00 0.5010692E+00 0.5010422E+00 0.5012148E+00
 0.5008195E+00
ENDOF FIELD
BEGIN FIELD
LOCAL SHEAR          2     5     0     1     1
 0.4987568E+02
ENDOF FIELD
BEGIN FIELD
TENSOR T             2     5     2     6     6
 0.3423216E+00-0.1325892E+00-0.5152607E+00 0.3440299E+03 0.6210741E+01
 0.1134446E+03
ENDOF FIELD
BEGIN FIELD
LOCAL MIXIN          2     5     0     1     1
 0.5183546E+00
ENDOF FIELD
BEGIN FIELD
Q-output            13     5     0     1     1
 0.5208735E-06
ENDOF FIELD
```

APPENDIX F.

Single-Flighted Conveying Screw Elements, Channel Flow - 2D Time Dependent Simulations

The 24mm pitched, single-flighted conveying screw elements channel flow simulations were represented using the following parameters.

Name of Mesh File:

24mmp.msh

Name of Data File:

24mtime.dat

New Task:

1 Task 1:

Method of Solving Problem:

F.E.M. task

Time dependent

Geometry:

2D planar geometry

Create a Sub-Task:

A Sub-Task 1:

Problem to be Solved:

Generalized Newtonian isothermal flow problem

Domain of the Sub-Task:

On sub-domain S1

B Sub-Task 2:

Problem to be Solved:

Generalized Newtonian isothermal flow problem

Domain of the Sub-Task:

On sub-domain S2

Titles Given to Sub-Tasks 1 and 2:

1 Liquid right

2 Liquid left

C Sub-Task 3:

Problem to be Solved:

Post-Processor

Title Given to Sub-Task 3:

3 Tracking

Domain of the Sub-Task:

On sub-domains S1+S2

Sub-Task 1: Liquid right

Material Data (Ideal Rheology for Polypropylene):

1 Shear-Rate Dependence of Viscosity:

Power Law (f(g) is a function of shear rate):

f(g) = fac*g**(expo-1)

Shear Rate Viscosity (poise):	fac = 4400
Power Index:	expo = 0.5

5 Density:

Density (kg m^{-3}): r0 = 800

6 Inertia Terms:

Inertia will be neglected in the momentum equations:

11 Gravity:

Gravity component (m sec^{-2}) $g_x = 0$, $g_y = 0$ and $g_z = 0$

Flow Boundary Conditions:

Boundary Number to Which Conditions Apply:

BS1: Moving outer wall

1 Normal & Tangential Velocities Imposed (v_n & v_s):

Normal velocity component (m sec^{-1}): $v_n = 0$

Tangential velocity component (m sec^{-1}): $v_s = 0.13$

Boundary Number to Which Conditions Apply:

BS2: Screw profile (stationary)

1 Normal & Tangential Velocities Imposed (v_n & v_s):

Normal velocity component (m sec^{-1}): $v_n = 0$

Tangential velocity component (m sec^{-1}): $v_s = 0$

Interface Conditions

Interface is imposed: Along subdomains S1 and S2

0 Interface

Moving interface

Surface tension force:

t_n = -gamma*1/R

Surface tension coefficient (kg sec^{-2}): gamma = 0 (No surface tension effect)

Global Remeshing:

Remeshing technique

2 Method of Spines

Remeshing inlet: Intersection with boundary 1

Remeshing outlet: Intersection with boundary 2

Element distortion check

No action is taken as long as the following distortion limits are not exceeded:

Minimum interior angle: = 5

Maximum interior angle: = 170

Maximum aspect ratio: = 10

Maximum bend: = 0.8

Maximum skew: = 10

Domain for rigid translation

The current translation is defined on an empty mesh

Rigid translation

Translational speed (m sec^{-1}): $U_x = 0$, $U_y = 0$ and $U_z = 0$

Sub-Task 2: Liquid left

Identical properties to Sub-task 1 used

Interpolation:

Linear coordinates

Quadratic velocities, linear pressure

Picard iterations on viscosity(g)

No upwinding in momentum equations

Numerical Parameters:

No previous solution

Coupled iterations of moving surfaces

Calculation of initial solution

Surface kinematic condition

Numerical Parameters for Iterations:

Maximum number of iterations	= 50
Convergence test	$= 1 \times 10^{-7}$
Divergence test	$= 1 \times 10^{3}$

Transient Iterative Parameters:

Initial time value	= 0
Upper time limit	= 10
Initial value of time step	$= 1 \times 10^{-2}$
Minimum admissible value of the time-step	$= 1 \times 10^{-4}$
Maximum admissible value of the time-step	$= 2.5 \times 10^{-1}$
Tolerance for time marching	$= 1 \times 10^{-3}$
Maximum number of successful steps	= 100
Method for the integration	Crank-Nicholson and Implicit Euler methods determined and results compared.

Assign the Pressure:

Field is shared by sub-tasks: S1 + S2

Pressure field is currently imposed at the node closest to the coordinates: x = 0 and y = 0.

Current value of the pressure condition is: P = 0 (Pa)

Assign the Stream Function:

Field is shared by sub-tasks: S1 + S2

The stream function currently vanishes at the node closest to the coordinates: x = 0 and y = 0

Mesh to Mesh Interpolation

None

Outputs

Output at each:	dt = 0.01
Current output(s):	Polyplot
Listing:	max
Check ADDR:	off

Appendix G:

Flow Problem Parameters as Seen Within Each Polydata Menu, for the Time-Dependent Simulation of the 2D Y-Z Screw Channel Flow, Representative of the Single-Flighted Conveying Screw Elements.

```
                         **********************
                         *                    *
                         *   P O L Y D A T A  *
                         *                    *
                         **********************

                      Version :  3.  4.  6.   1

        # - Save and exit
        1 - Read a mesh file                         (enter  1 or CR)
        2 - Read and optimize a mesh file            (enter  2)
        3 - Convert a mesh file                      (enter  3)
        4 - Filename syntax                          (enter  4)
        # - Outputs
        # - Read an old data file
        # - Create a new task
        # - Redefine global parameters of a task

 Enter your choice

 Enter the name of the mesh file (default = msh)

24mmp.msh


 Is it a formatted file
 Enter y(es) or n(o)   (CR=yes)

Loading the mesh data ...


                         **********************
                         *                    *
                         *   P O L Y D A T A  *
                         *                    *
                         **********************

                      Version :  3.  4.  6.   1

        # - Save and exit
        # - Read a mesh file
        # - Read and optimize a mesh file
        3 - Convert a mesh file                      (enter  3)
        4 - Filename syntax                          (enter  4)
        # - Outputs
        6 - Read an old data file                    (enter  6)
        7 - Create a new task                        (enter  7 or CR)
        # - Redefine global parameters of a task

 Enter your choice
6

 Enter the name of the old data file (default = dat)

24mtime.dat

 Loading the data ...

 Checking the data ...
```

```
***************
*             *
*   Outputs   *
*             *
***************
 Output at each dt =  0.100E-01
Current output(s) : Polyplot
Listing           : max
Check ADDR        : off

 -1 - Upper level menu          (enter -1 or CR)
  0 - Output Triggering         (enter  0)
  1 - Disable Polyplot output   (enter  1)
  2 - Enable Patran output      (enter  2)
  3 - Enable Supertab output    (enter  3)
  4 - Enable DataVisual output  (enter  4)
  # - Enable Explorer output
  6 - Enable CFView-PF output   (enter  6)
  7 - Enable Polyflow output    (enter  7)
  8 - Listing    : none         (enter  8)
  9 - Listing    : min          (enter  9)
 10 - Listing    : max          (enter 10)
 11 - Enable  ADDR check        (enter 11)

Enter your choice
```

||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

```
*****************************************
*                                       *
*   Redefine global parameters of a task   *
*                                       *
*****************************************

    Current setup : - F.E.M. task
                    - Time-dependent
                    - 2D planar geometry

  -2 - Delete the current task       (enter -2)
  -1 - Accept the current setup      (enter -1 or CR)
 > 1 - F.E.M. task                   (enter  1)
   # - MIXING task
   3 - Steady-state problem(s)       (enter  3)
 > 4 - Time-dependent problem(s)     (enter  4)
   5 - Evolution problem(s)          (enter  5)
   6 - Rigid rotation                (enter  6)
 > 7 - 2D planar geometry            (enter  7)
   # - 2D axisymmetric geometry
   9 - 2D 1/2 planar geometry        (enter  9)
   # - 2D 1/2 axisymmetric geometry

Enter your choice
```

||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

```
                         *********************
                         *                   *
                         *   F.E.M. Task  1  *
                         *                   *
                         *********************

          -1 - Upper level menu                                   (enter -1 or CR)
           1 - Numerical parameters                               (enter  1)
           2 - Create a sub-task                                  (enter  2)
           3 - Redefine global parameters of a sub-task           (enter  3)
           4 - Assign the pressure                                (enter  4)
           5 - Assign the stream function                         (enter  5)
           6 - Mesh-mesh interpolation                            (enter  6)
           # - Define species
           # - Define reactions
           9 - Liquid right                                       (enter  9)
          10 - Liquid Left                                        (enter 10)
          11 - Tracking                                           (enter 11)

 Enter your choice
1

                   **************************
                   *                        *
                   *   Numerical parameters *
                   *                        *
                   **************************

            - No previous solution
            - Coupled computation of moving surfaces
            - Calculation of initial solution.
            - Surface kinematic condition

     -1 - Upper level menu                                        (enter -1 or CR)
      1 - No previous solution                                    (enter  1)
      2 - Start with an old result file                           (enter  2)
      3 - Start with an old result file and a restart file        (enter  3)
      4 - Modify numerical parameters for iterations              (enter  4)
      # - Modify pathname of the old result file
      # - Modify pathname of the restart file
      7 - Decoupled computation of moving surfaces                (enter  7)
      # - Modify the max number of 'fixed' iterations
      # - Modify the convergence test ('fixed' iterations)
     10 - Modify the evolution par. for moving bound.             (enter 10)
     11 - Modify the transient iterative parameters               (enter 11)
     12 - Cancel the computation of initial solution              (enter 12)
      # - Line kinematic condition

 Enter your choice

4

            ******************************************
            *                                        *
            *   Numerical parameters for iterations  *
            *                                        *
            ******************************************

       - Maximum number of iterations               =      50
       - Convergence test                           =   1.0000000E-07
       - Divergence test                            =   1.0000000E+03

      -1 - Upper level menu                         (enter -1 or CR)
       1 - Modify of the max number of iterations   (enter  1)
       2 - Modify of the convergence test           (enter  2)
       3 - Modify of the divergence test            (enter  3)

 Enter your choice
```

```
***************************************
*                                     *
*   Transient iterative  parameters   *
*                                     *
***************************************

   - Initial time value                        =  0.0000000E+00
   - Upper time limit                          =  1.0000000E+01
   - Initial value of the time step            =  1.0000000E-02
   - Min admissible value of the time-step =  1.0000000E-04
   - Max admissible value of the time-step =  2.5000000E-01
   - Tolerance for time marching               =  1.0000000E-03
   - Max number of successful steps            =   100
   - Use of the Crank-Nicholson method for the integration

 -1 - Upper level menu                           (enter -1 or CR)
  1 - Modify the initial time value              (enter  1)
  2 - Modify the upper time limit                (enter  2)
  3 - Modify the initial value of the time-step (enter  3)
  4 - Modify the min value of the time-step      (enter  4)
  5 - Modify the max value of the time-step      (enter  5)
  6 - Modify the tolerance                       (enter  6)
  7 - Modify the max number of successful steps (enter  7)
  # - Use of the 0-order method
  9 - Use of the implicit Euler method           (enter  9)
 10 - Use of the Galerkin method                 (enter 10)
 11 - Use of the Crank-Nicholson method          (enter 11)
 12 - Disable prediction of velocity field       (enter 12)

Enter your choice

**************************
*                        *
*   Assign the pressure  *
*                        *
**************************

 The calculation of the pressure field associated
with the following velocity field requires a point at
which the value of the pressure is imposed.

 1 : Field shared by sub-tasks- Liquid right
                              - Liquid Left

-1 - Upper level menu                 (enter -1 or CR)
 1 - Pressure condition for field  1 (enter  1)

Enter your choice

1

*************************
*                       *
*   Pressure condition  *
*                       *
*************************

 The pressure field is currently imposed at the node
closest to coordinates :

          X = 0.0000000E+00  Y = 0.0000000E+00

Do you agree with this ?
Enter y(es) or n(o)  (CR=yes)

Current value of pressure condition is  0.0000000E+00
Enter its new value  (CR=no modification)
```

```
***********************************
*                                 *
*   Assign the stream function    *
*                                 *
***********************************

 The calculation of the stream function PSI associated
with the following velocity or Darcy pressure field
requires a point at which PSI equals to zero.

 1 : Field shared by sub-tasks- Liquid right
                              - Liquid Left

 -1 - Upper level menu                                (enter -1 or CR)
  1 - Condition on the stream function for field  1 (enter  1)

 Enter your choice
1

***************************************
*                                     *
*   Condition on the stream function  *
*                                     *
***************************************

 The stream function currently vanishes at the node
closest to coordinates :

            X = 0.0000000E+00  Y = 0.0000000E+00

Do you agree with this ?
Enter y(es) or n(o)  (CR=yes)

******************************
*                            *
*   Mesh-mesh interpolation  *
*                            *
******************************

Mesh-mesh interpolations interpolate all potential
velocity, pressure, temperature, and stress fields
from a previous result to the current task.

Such an interpolation has not yet been defined.

    -1 - Accept current setup  (enter -1 or CR)
     1 - Create interpolations (enter  1)
     # - Modify file names

Enter your choice

***********************************************
*                                             *
*   Redefine global parameters of a sub-task  *
*                                             *
***********************************************

              Sub-task : Liquid right

 -1 - Upper level menu                           (enter -1 or CR)
  1 - Delete the current sub-task                (enter  1)
  2 - Modify the title of the current sub-task   (enter  2)
  3 - Modify the type of the current sub-task    (enter  3)

Enter your choice

3
```

```
*********************************************
*                                           *
*   Redefine global parameters of a sub-task   *
*                                           *
*********************************************


 > 1 - Generalized Newtonian isothermal flow problem        (enter  1 or
CR)
   2 - Generalized Newtonian non-isothermal flow problem    (enter  2)
   3 - Heat conduction problem                              (enter  3)
   # - Differential viscoelastic isothermal flow problem
   # - Differential viscoelastic non-isothermal flow problem
   # - Postprocessor
   # - Integral viscoelastic isothermal flow problem
   # - Integral viscoelastic non-isothermal flow problem
   9 - Darcy isothermal flow problem                        (enter  9)
  10 - Darcy non-isothermal flow problem                    (enter 10)
  11 - Slightly compressible flow problem                   (enter 11)
   # - Mass transfer problem
  13 - Potential problem                                    (enter 13)
  14 - Film model : Gen. Newtonian isothermal               (enter 14)
  15 - Film model : Gen. Newtonian non-isothermal           (enter 15)
   # - Film model : Viscoelastic isothermal
   # - Thickness for film
   # - Transport of species
   # - Closure

 Enter your choice


|||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||


                    *******************
                    *                 *
                    *   Liquid right  *
                    *                 *
                    *******************


          -1 - Upper level menu            (enter -1 or CR)
           1 - Domain of the sub-task      (enter  1)
           2 - Material data               (enter  2)
           3 - Flow boundary conditions    (enter  3)
           4 - Global remeshing            (enter  4)
           5 - Rigid translation           (enter  5)
           6 - Interpolation               (enter  6)
           # - Bubbling

 Enter your choice

1
                *****************************
                *                           *
                *   Domain of the sub-task  *
                *                           *
                *****************************

            The current sub-task is defined on : S1.

        -2 - Make the current domain empty (enter -2)
        -1 - Upper level menu              (enter -1 or CR)
         0 - Extension to the whole mesh   (enter  0)
         1 - Removal of subdomain  1       (enter  1)
         2 - Addition of subdomain  2      (enter  2)

 Enter your choice
```

```
                    ********************
                    *                  *
                    *   Material data  *
                    *                  *
                    ********************


   -1 - Upper level menu                           (enter -1 or CR)
    1 - Shear-rate dependence of viscosity         (enter  1)
    # - Temperature dependence of viscosity
    # - Differential viscoelastic models
    # - Integral Viscoelastic models
    5 - Density                                    (enter  5)
    6 - Inertia terms                              (enter  6)
    # - Coefficient of thermal expansion
    # - Thermal conductivity
    # - Heat capacity per unit mass
    # - Viscous heating
   11 - Gravity                                    (enter 11)
    # - Average temperature
    # - Heat source per unit volume

 Enter your choice

1

          *****************************************
          *                                       *
          *   Shear-rate dependence of viscosity  *
          *                                       *
          *****************************************


           -1 - Upper level menu     (enter -1 or CR)
            1 - Constant viscosity   (enter  1)
            2 - Bird-Carreau law     (enter  2)
          > 3 - Power law            (enter  3)
            4 - Bingham law          (enter  4)
            5 - Herschel-Bulkley law (enter  5)
            6 - Cross law            (enter  6)

 Enter your choice

3

                    ****************
                    *              *
                    *   Power law  *
                    *              *
                    ****************

                    f(g) = fac * g**(expo-1)

  fac          =  4.4000000E+03      expo         =  5.0000000E-01

           -1 - Upper level menu     (enter -1 or CR)
            1 - Modification of fac  (enter  1)
            2 - Modification of expo (enter  2)

 Enter your choice
```

```
                        **************
                        *            *
                        *  Density   *
                        *            *
                        **************


                 density        =  8.0000000E+02

           -1 - Upper level menu         (enter -1 or CR)
            1 - Modification of density (enter  1)

Enter your choice

                     ********************
                     *                  *
                     *  Inertia terms   *
                     *                  *
                     ********************

Inertia will be neglected in the momentum equations

Do you agree with this ?
Enter y(es) or n(o)  (CR=yes)


                        **************
                        *            *
                        *  Gravity   *
                        *            *
                        **************


         gx          =  0.0000000E+00       gy          =  0.0000000E+00
         gz          =  0.0000000E+00

              -1 - Upper level menu   (enter -1 or CR)
               1 - Modification of gx (enter  1)
               2 - Modification of gy (enter  2)
               # - Modification of gz

Enter your choice
```

||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

```
                 ********************************
                 *                              *
                 *   Flow boundary conditions   *
                 *                              *
                 ********************************


          -1 - Upper level menu                        (enter -1 or CR)
           # - Normal flow rate imposed
           1 - Interface along subdomain  2            (enter  1)
           2 - vn & vs imposed along boundary  1       (enter  2)
           3 - vn & vs imposed along boundary  2       (enter  3)

Select the boundary condition you want to modify

1
```

```
*****************************************
*                                       *
*   Flow boundary condition along subdomain  2   *
*                                       *
*****************************************

          Current choice : Interface
                           No force postprocessor

 -2 - Enable force postprocessor                         (enter -2)
 -1 - Upper level menu                                   (enter -1 or
CR)
> 0 - Interface                                          (enter  0)
  1 - Normal and tangential velocities imposed  (vn & vs) (enter  1)
  2 - Normal and tangential forces imposed  (fn & fs)     (enter  2)
  3 - Normal velocity and tangential force imposed  (vn & fs) (enter  3)
  4 - Normal force and tangential velocity imposed  (fn & vs) (enter  4)
  5 - Slip conditions                                    (enter  5)
  6 - Plane of symmetry  ( fs=0 & vn=0 )                 (enter  6)
  7 - Inflow                                             (enter  7)
  8 - Outflow                                            (enter  8)
  # - Free surface
 10 - Global force imposed                               (enter 10)
 11 - Cartesian velocities imposed  (vx,vy)              (enter 11)

 Enter your choice

0
                    ****************
                    *              *
                    *   Interface  *
                    *              *
                    ****************

              The current setup is :

                 - Moving interface
                 - No Surface tension effect

      -1 - Accept the current setup              (enter -1 or CR)
       1 - Define a fixed interface              (enter  1)
       2 - Modify the moving interface parameters (enter  2)

 Enter your choice

2

                ***************************
                *                         *
                *   Kinematic condition   *
                *                         *
                ***************************


       -1 - Upper level menu                      (enter -1 or CR)
        1 - Surface tension                       (enter  1)
        2 - Boundary conditions                   (enter  2)
        # - Normal force
        4 - Direction of motion                   (enter  4)
        5 - Contact (Blow mold.)                  (enter  5)
        6 - Upwinding in the kinematic equation   (enter  6)
        7 - Outlet (Inv. prediction)              (enter  7)
        # - Drag

 Enter your choice
1
```

```
                    ********************
                    *                  *
                    *  Surface tension *
                    *                  *
                    ********************

          Surface tension :

             tn = - gamma * 1/R
            where : gamma = surface tension coefficient
                    R     = local radius of curvature

 Current value of gamma is  0.0000000E+00
 Enter its new value  (CR=no modification)


        ************************************************
        *                                              *
        *   Flow boundary condition along boundary  1  *
        *                                              *
        ************************************************

              Current choice : vn & vs imposed
                               No force postprocessor

 -2 - Enable force postprocessor                                (enter -2)
 -1 - Upper level menu                                          (enter -1 or
CR)
  # - Interface
> 1 - Normal and tangential velocities imposed  (vn & vs)       (enter  1)
  2 - Normal and tangential forces imposed  (fn & fs)           (enter  2)
  3 - Normal velocity and tangential force imposed  (vn & fs)   (enter  3)
  4 - Normal force and tangential velocity imposed  (fn & vs)   (enter  4)
  5 - Slip conditions                                           (enter  5)
  6 - Plane of symmetry  ( fs=0 & vn=0 )                        (enter  6)
  7 - Inflow                                                    (enter  7)
  8 - Outflow                                                   (enter  8)
  9 - Free surface                                              (enter  9)
 10 - Global force imposed                                      (enter 10)
 11 - Cartesian velocities imposed  (vx,vy)                     (enter 11)

 Enter your choice

1

            ****************************************
            *                                      *
            *   vn & vs imposed along boundary  1  *
            *                                      *
            ****************************************

               -   vn  : constant =  0.0000000E+00

      -1 - Upper level menu                    (enter -1 or CR)
       1 - Constant                            (enter  1)
       2 - Linear function of coordinates      (enter  2)

 Enter your choice
```

```
            ***************************************
            *                                     *
            *   vn & vs imposed along boundary  1 *
            *                                     *
            ***************************************

               -   vs  : constant =  1.3000000E-01

        -1 - Upper level menu               (enter -1 or CR)
         1 - Constant                       (enter  1)
         2 - Linear function of coordinates (enter  2)

 Enter your choice


         *********************************************
         *                                           *
         *  Flow boundary condition along boundary 2 *
         *                                           *
         *********************************************

              Current choice : vn & vs imposed
                               No force postprocessor

 -2 - Enable force postprocessor                              (enter -2)
 -1 - Upper level menu                                        (enter -1 or
CR)
  # - Interface
> 1 - Normal and tangential velocities imposed  (vn & vs)     (enter  1)
  2 - Normal and tangential forces imposed  (fn & fs)         (enter  2)
  3 - Normal velocity and tangential force imposed  (vn & fs) (enter  3)
  4 - Normal force and tangential velocity imposed  (fn & vs) (enter  4)
  5 - Slip conditions                                         (enter  5)
  6 - Plane of symmetry  ( fs=0 & vn=0 )                      (enter  6)
  7 - Inflow                                                  (enter  7)
  8 - Outflow                                                 (enter  8)
  9 - Free surface                                            (enter  9)
 10 - Global force imposed                                    (enter 10)
 11 - Cartesian velocities imposed  (vx,vy)                   (enter 11)

 Enter your choice

1


            ***************************************
            *                                     *
            *   vn & vs imposed along boundary  2 *
            *                                     *
            ***************************************

               -   vn  : constant =  0.0000000E+00

        -1 - Upper level menu               (enter -1 or CR)
         1 - Constant                       (enter  1)
         2 - Linear function of coordinates (enter  2)

 Enter your choice
```

```
**********************************
*                                *
*   vn & vs imposed along boundary  2   *
*                                *
**********************************

   -   vs  : constant =  0.0000000E+00

 -1 - Upper level menu                  (enter -1 or CR)
  1 - Constant                          (enter  1)
  2 - Linear function of coordinates    (enter  2)

Enter your choice
```

||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

```
**********************
*                    *
*  Global remeshing  *
*                    *
**********************

 -3 - Enable the inverse prediction (enter -3)
  # - Deletion of a local remeshing
 -1 - Upper level menu              (enter -1 or CR)
  # - Creation of a local remeshing
  1 -  1-st local remeshing         (enter  1)

Enter your choice

1

****************************
*                          *
*  Local remeshing domain  *
*                          *
****************************

     The current remeshing is defined on : S1.

 -2 - Make the current domain empty (enter -2)
 -1 - Upper level menu              (enter -1 or CR)
  # - Extension to the whole mesh
  1 - Removal  of subdomain  1      (enter  1)
  # - Addition of subdomain  2

Enter your choice

*************************
*                       *
*  Remeshing technique  *
*                       *
*************************

  # - Adaptative section for prediction
  # - Constant section for prediction
  1 - Thomp. Transform                (enter  1)
> 2 - Method of Spines                (enter  2 or CR)
  3 - Euclidian Method                (enter  3)
  4 - Thin Shell Method               (enter  4)
  5 - Optimesh                        (enter  5)

Enter your choice
2
```

```
**********************
*                    *
*   Remeshing inlet  *
*                    *
**********************

The inlet of the system of spines is defined by
the intersection with boundary    1

Do you agree with this ?
Enter y(es) or n(o)  (CR=yes)

**********************
*                    *
*   Remeshing outlet *
*                    *
**********************

The outlet of the system of spines is defined by
the intersection with boundary    2

Do you agree with this ?
Enter y(es) or n(o)  (CR=yes)

******************************
*                            *
*   Element distortion check *
*                            *
******************************

     Current setup : - no action if distortion limits exceeded
                     - min interior angle =  5.0000000E+00
                     - max interior angle =  1.7000000E+02
                     - max aspect ratio   =  1.0000000E+01
                     - max bend           =  8.0000000E-01
                     - max skew           =  1.0000000E+01

    -1 - Accept the current setup                   (enter -1 or CR)
     1 - No action if distortion limits exceeded    (enter  1)
     2 -  Warning  if distortion limits exceeded    (enter  2)
     3 -   Stop    if distortion limits exceeded    (enter  3)
     4 - Modification of the minimum interior angle (enter  4)
     5 - Modification of the maximum interior angle (enter  5)
     6 - Modification of the maximum aspect ratio   (enter  6)
     7 - Modification of the maximum bend           (enter  7)
     8 - Modification of the maximum skew           (enter  8)

Enter your choice

*********************************
*                               *
*   Domain for rigid translation *
*                               *
*********************************

     The current translation is defined on : empty mesh.

      # - Make the current domain empty
     -1 - Upper level menu                (enter -1 or CR)
      # - Extension to the whole mesh
      1 - Addition of subdomain  1        (enter  1)

Enter your choice
```

```
*************************
*                       *
*   Rigid translation   *
*                       *
*************************

Translation speed : d/dt (X, Y, Z) = (Ux, Uy, Uz)

        Ux            =  0.0000000E+00      Uy            =  0.0000000E+00
        Uz            =  0.0000000E+00

                 -1 - Upper level menu    (enter -1 or CR)
                  1 - Modification of Ux  (enter  1)
                  2 - Modification of Uy  (enter  2)
                  # - Modification of Uz

Enter your choice

||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

*********************
*                   *
*   Interpolation   *
*                   *
*********************

        Current setup : Linear coordinates
                        Quadratic velocities, linear pressure
                        Picard iterations on viscosity(g)
                        No upwinding in momentum equations

   -1 - Upper level menu                                      (enter -1 or
CR)
    1 - Quadratic coordinates                                 (enter  1)
    # - Quadratic element for stresses
    # - 4x4 SU element for stresses
    # - 4x4 SUPG element for stresses
    # - EVSS for stresses
    # - EVSS SU for stresses
    # - EVSS SUPG for stresses
    8 - Quadratic velocities, linear pressure                 (enter  8)
    # - Mini-element for velocities, constant pressure
   10 - Linear velocities, constant pressure                  (enter 10)
   11 - Quadratic velocities, linear discontinuous pressure   (enter 11)
   12 - Newton iterations on viscosity(g)                     (enter 12)
    # - Linear    element for temperature
    # - Quadratic element for temperature
    # - 2x2       element for temperature
    # - 4x4       element for temperature
    # - Upwinding in momentum equations
    # - Sub-interpolation

Enter your choice
```

```
||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

                    ****************
                    *              *
                    *   Tracking   *
                    *              *
                    ****************

          -1 - Upper level menu                  (enter -1)
           1 - Local shear-rate                  (enter  1)
           2 - Viscosity                         (enter  2)
           3 - Rate of deformation tensor        (enter  3)
           4 - Inelastic stress tensor           (enter  4)
           5 - Viscous heating                   (enter  5)
           # - Total extra-stress tensor
           7 - Residence time                    (enter  7)
           8 - Tracking of material points       (enter  8 or CR)
           9 - Tracking of a material property  (enter  9)
          10 - Forces on slices                  (enter 10)

Enter your choice


The calculation will be done on (S1+S2).

Hit CR to continue
```

APPENDIX H

Single-Flighted Conveying Screw Elements - 3D Steady State Simulations

3D single-flighted conveying screw elements simulations were represented using the following parameters.

Name of Mesh File:

double2.msh

Name of Data File:

double2.dat

New Task:

1 Task 1:

Method of Solving Problem:

F.E.M. task

Steady-state

Create a Sub-Task:

A Sub-Task 1:

Problem to be Solved:

Generalized Newtonian isothermal flow problem

Title Given to Sub-Task 1:

1 3D Rotation

B Sub-Task 2 - 5:

Problem to be Solved:

Post-Processor

Titles Given to Sub-Task 2 - 8:

2 Local shear-rate (& average value)

3 Inelastic stress tensor (& average value)

4 Mixing efficiency (& average value)

5 Outflow (through outlet BS8)

Domain of the Sub-Tasks:

Over whole mesh

Material Data (Ideal Rheology for Polypropylene):

1 Shear-Rate Dependence of Viscosity:

Power Law (f(g) is a function of shear rate):

f(g) = fac*g**(expo-1)

Shear Rate Viscosity (poise): fac = 4400

Power Index: expo = 0.5

5 Density:

Density (kg m^{-3}): r0 = 800

6 Inertia Terms:

Inertia will be neglected in the momentum equations:

11 Gravity:

Gravity component (m sec^{-2}) $g_x = 0$, $g_y = -9.81$ and $g_z = 0$

The g_y = -9.81 value is not taken into account within momentum equations, as only volumetric gravity force is considered within Polyflow.

Flow Boundary Conditions:

Boundary Number to Which Conditions Apply:

BS1: Inlet

6 Inflow

Volumetric flow rate (m^3 sec^{-1}) $= 5.20 \times 10^{-7}$

Boundary Number to Which Conditions Apply:

BS2: Right Hand Element (rotating at 1 revolution per second).

11 Cartesian Velocities Imposed (v_x, v_y):

Coordinates of 1st rotation centre (m): x = -0.017505, y = 0 and z = 0

Coordinates of 2nd rotation centre (m): x = -0.012505, y = 0 and z = -0.01647

Angular velocity (rad sec^{-1}) : $v = 2\pi$

(Positive value indicates counter-clockwise direction).

Components of translation velocity (m sec^{-1}): $t_x = 0$, $t_y = 0$ and $t_z = 0$

Boundary Number to Which Conditions Apply:

BS3: Crossover Region (rotating at 1 revolution per second).

11 Cartesian Velocities Imposed (v_x, v_y):

Coordinates of 1st rotation centre (m): $x = 0$, $y = 0.019865$ and $z = 0$

Coordinates of 2nd rotation centre (m): $x = 0.005$, $y = 0.019865$ and $z = -0.01647$

Angular velocity (rad sec^{-1}) : $v = -2\pi$

(Negative value indicates clockwise direction).

Components of translation velocity (m sec^{-1}): $t_x = 0$, $t_y = 0$ and $t_z = 0$

Boundary Number to Which Conditions Apply:

BS4: Crossover Region (rotating at 1 revolution per second).

11 Cartesian Velocities Imposed (v_x, v_y):

Coordinates of 1st rotation centre (m): $x = 0$, $y = 0.019865$ and $z = 0$

Coordinates of 2nd rotation centre (m): $x = 0.005$, $y = 0.019865$ and $z = -0.01647$

Angular velocity (rad sec^{-1}) : $v = -2\pi$

(Negative value indicates clockwise direction).

Components of translation velocity (m sec^{-1}): $t_x = 0$, $t_y = 0$ and $t_z = 0$

Boundary Number to Which Conditions Apply:

BS5: Left Hand Element (rotating at 1 revolution per second).

11 Cartesian Velocities Imposed (v_x, v_y):

Coordinates of 1st rotation centre (m): $x = 0.017505$, $y = 0$ and $z = 0$

Coordinates of 2nd rotation centre (m): $x = 0.022505$, $y = 0$ and $z = -0.01647$

Angular velocity (rad sec^{-1}) : $v = 2\pi$

(Positive value indicates counter-clockwise direction).

Components of translation velocity (m sec^{-1}): $t_x = 0$, $t_y = 0$ and $t_z = 0$

Boundary Number to Which Conditions Apply:

BS6: Left Hand Element - Additional Face (rotating at 1 revolution per second).

11 Cartesian Velocities Imposed (v_x, v_y):

Coordinates of 1st rotation centre (m): $x = 0.017505$, $y = 0$ and $z = 0$

Coordinates of 2nd rotation centre (m): $x = 0.022505$, $y = 0$ & $z = -0.01647$

Angular velocity (rad sec^{-1}) : $v = 2\pi$

(Positive value indicates counter-clockwise direction).

Components of translation velocity (m sec^{-1}): $t_x = 0$, $t_y = 0$ and $t_z = 0$

Boundary Number to Which Conditions Apply:

BS7: Outer Figure-of-Eight Barrel (non-slip boundary).

1 Normal & Tangential Velocities Imposed (v_n & v_s):

Normal velocity component (m sec^{-1}): $v_n = 0$

Tangential velocity component (m sec^{-1}): $v_s = 0$

Boundary Number to Which Conditions Apply:

BS8: Outlet.

7 Outflow

Zero normal force imposed

Interpolation:

Linear coordinates

Quadratic velocities, linear pressure

Picard iterations on viscosity(g)

No upwinding in momentum equations

Numerical Parameters:

No previous solution

Maximum number of iterations	= 50
Convergence test	$= 1 \times 10^{-8}$
Divergence test	$= 1 \times 10^{3}$

Coupled iterations for moving boundaries

Surface kinematic condition

Mesh to Mesh Interpolation

None

Outputs

Current output(s):	CFView-PF
Listing:	max
Check ADDR:	off

Appendix I:

Flow Problem Parameters as Seen Within Each Polydata Menu, for the Steady State Simulation of the 3D half profile, Representative of the Single-Flighted Conveying Screw Elements.

```
                    **********************
                    *                    *
                    *   P O L Y D A T A  *
                    *                    *
                    **********************

                  Version :  3.  4.  6.   1

       # - Save and exit
       1 - Read a mesh file                      (enter  1 or CR)
       2 - Read and optimize a mesh file         (enter  2)
       3 - Convert a mesh file                   (enter  3)
       4 - Filename syntax                       (enter  4)
       # - Outputs
       # - Read an old data file
       # - Create a new task
       # - Redefine global parameters of a task

 Enter your choice


 Enter the name of the mesh file (default = msh)

double2.msh

 Is it a formatted file
 Enter y(es) or n(o)  (CR=yes)

 Loading the mesh data ...

                    **********************
                    *                    *
                    *   P O L Y D A T A  *
                    *                    *
                    **********************

                  Version :  3.  4.  6.   1

       # - Save and exit
       # - Read a mesh file
       # - Read and optimize a mesh file
       3 - Convert a mesh file                   (enter  3)
       4 - Filename syntax                       (enter  4)
       # - Outputs
       6 - Read an old data file                 (enter  6)
       7 - Create a new task                     (enter  7 or CR)
       # - Redefine global parameters of a task

 Enter your choice
6

 Enter the name of the old data file (default = dat)

double2.dat

 Loading the data ...

 Checking the data ...
```

```
                    ***********************
                    *                     *
                    *   P O L Y D A T A   *
                    *                     *
                    ***********************

                  Version :  3.  4.  6.   1

     0 - Save and exit                         (enter  0)
     # - Read a mesh file
     # - Read and optimize a mesh file
     3 - Convert a mesh file                   (enter  3)
     4 - Filename syntax                       (enter  4)
     5 - Outputs                               (enter  5)
     # - Read an old data file
     7 - Create a new task                     (enter  7)
     8 - Redefine global parameters of a task  (enter  8)
     9 - F.E.M. Task  1                        (enter  9)

 Enter your choice
5


||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

                       ***************
                       *             *
                       *   Outputs   *
                       *             *
                       ***************

                Current output(s) : CFView-PF
                Listing           : max
                Check ADDR        : off

         -1 - Upper level menu          (enter -1 or CR)
          # - Output Triggering
          1 - Enable 3DCross output     (enter  1)
          2 - Enable Patran output      (enter  2)
          3 - Enable Supertab output    (enter  3)
          4 - Enable DataVisual output  (enter  4)
          # - Enable Explorer output
          6 - Disable CFView-PF output  (enter  6)
          7 - Enable Polyflow output    (enter  7)
          8 - Listing   : none          (enter  8)
          9 - Listing   : min           (enter  9)
         10 - Listing   : max           (enter 10)
         11 - Enable  ADDR check        (enter 11)

 Enter your choice
```

```
******************************************
*                                        *
*   Redefine global parameters of a task *
*                                        *
******************************************

      Current setup : - F.E.M. task
                      - Steady-state

  -2 - Delete the current task   (enter -2)
  -1 - Accept the current setup  (enter -1 or CR)
> 1 - F.E.M. task                (enter  1)
  # - MIXING task
> 3 - Steady-state problem(s)    (enter  3)
  4 - Time-dependent problem(s)  (enter  4)
  5 - Evolution problem(s)       (enter  5)
  6 - Rigid rotation             (enter  6)

Enter your choice
```

||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

```
*********************
*                   *
*   F.E.M. Task  1  *
*                   *
*********************

-1 - Upper level menu                             (enter -1 or CR)
 1 - Numerical parameters                         (enter  1)
 2 - Create a sub-task                            (enter  2)
 3 - Redefine global parameters of a sub-task     (enter  3)
 # - Assign the pressure
 # - Assign the stream function
 6 - Mesh-mesh interpolation                      (enter  6)
 # - Define species
 # - Define reactions
 9 - 3D Rotation                                  (enter  9)
10 - Local shear-rate                             (enter 10)
11 - Inelastic stress tensor                      (enter 11)
12 - Mixing efficiency                            (enter 12)

Enter your choice
1

***************************
*                         *
*   Numerical parameters  *
*                         *
***************************

  - No previous solution
  - Maximum number of iterations          =     50
  - Convergence test                      =   1.0000000E-08
  - Divergence test                       =   1.0000000E+03
  - Coupled iterations for moving bound.
  - Surface kinematic condition

 -1 - Upper level menu                              (enter -1 or CR)
  1 - Start with an old result file                 (enter  1)
  2 - Modify the max number of iterations           (enter  2)
  3 - Modify the convergence test                   (enter  3)
  4 - Modify the divergence test                    (enter  4)
  5 - Decoupled iterations for moving bound.        (enter  5)
  # - Modify the max number of 'fixed' iterations
  # - Modify the convergence test ('fixed' iterations)
  8 - Line kinematic condition                      (enter  8)

Enter your choice
```

```
                    ******************************
                    *                            *
                    *   Mesh-mesh interpolation  *
                    *                            *
                    ******************************

          Mesh-mesh interpolations interpolate all potential
          velocity, pressure, temperature, and stress fields
          from a previous result to the current task.

          Such an interpolation has not yet been defined.

              -1 - Accept current setup  (enter -1 or CR)
               1 - Create interpolations (enter  1)
               # - Modify file names

 Enter your choice


           **********************************************
           *                                            *
           *   Redefine global parameters of a sub-task *
           *                                            *
           **********************************************

                       Sub-task : 3D Rotation

       -1 - Upper level menu                        (enter -1 or CR)
        1 - Delete the current sub-task             (enter  1)
        2 - Modify the title of the current sub-task (enter  2)
        3 - Modify the type of the current sub-task  (enter  3)

 Enter your choice
3


           **********************************************
           *                                            *
           *   Redefine global parameters of a sub-task *
           *                                            *
           **********************************************


 > 1 - Generalized Newtonian isothermal flow problem         (enter  1 or
CR)
   2 - Generalized Newtonian non-isothermal flow problem     (enter  2)
   3 - Heat conduction problem                               (enter  3)
   4 - Differential viscoelastic isothermal flow problem     (enter  4)
   5 - Differential viscoelastic non-isothermal flow problem (enter  5)
   # - Postprocessor
   7 - Integral viscoelastic isothermal flow problem         (enter  7)
   8 - Integral viscoelastic non-isothermal flow problem     (enter  8)
   9 - Darcy isothermal flow problem                         (enter  9)
  10 - Darcy non-isothermal flow problem                     (enter 10)
  11 - Slightly compressible flow problem                    (enter 11)
   # - Mass transfer problem
  13 - Potential problem                                     (enter 13)
   # - Film model : Gen. Newtonian isothermal
   # - Film model : Gen. Newtonian non-isothermal
   # - Film model : Viscoelastic isothermal
   # - Thickness for film
   # - Transport of species
   # - Closure

 Enter your choice
```

```
                   ******************
                   *                *
                   *   3D Rotation  *
                   *                *
                   ******************


        -1 - Upper level menu          (enter -1 or CR)
         1 - Domain of the sub-task    (enter  1)
         2 - Material data             (enter  2)
         3 - Flow boundary conditions  (enter  3)
         # - Global remeshing
         # - Rigid translation
         6 - Interpolation             (enter  6)
         # - Bubbling

 Enter your choice
1

              ******************************
              *                            *
              *   Domain of the sub-task   *
              *                            *
              ******************************

       The current sub-task is defined on : whole mesh

      -2 - Make the current domain empty (enter -2)
      -1 - Upper level menu              (enter -1 or CR)
       # - Extension to the whole mesh
       1 - Removal of subdomain  1       (enter  1)

 Enter your choice


                   ********************
                   *                  *
                   *   Material data  *
                   *                  *
                   ********************


     -1 - Upper level menu                    (enter -1 or CR)
      1 - Shear-rate dependence of viscosity  (enter  1)
      # - Temperature dependence of viscosity
      # - Differential viscoelastic models
      # - Integral Viscoelastic models
      5 - Density                             (enter  5)
      6 - Inertia terms                       (enter  6)
      # - Coefficient of thermal expansion
      # - Thermal conductivity
      # - Heat capacity per unit mass
      # - Viscous heating
     11 - Gravity                             (enter 11)
      # - Average temperature
      # - Heat source per unit volume

 Enter your choice

1
```

```
                  *****************************************
                  *                                       *
                  *   Shear-rate dependence of viscosity  *
                  *                                       *
                  *****************************************


                   -1 - Upper level menu     (enter -1 or CR)
                    1 - Constant viscosity   (enter  1)
                    2 - Bird-Carreau law     (enter  2)
                  > 3 - Power law            (enter  3)
                    4 - Bingham law          (enter  4)
                    5 - Herschel-Bulkley law (enter  5)
                    6 - Cross law            (enter  6)

 Enter your choice

3


                              ****************
                              *              *
                              *   Power law  *
                              *              *
                              ****************

                              f(g) = fac * g**(expo-1)

          fac        =  4.4000000E+03     expo        =  5.0000000E-01

                   -1 - Upper level menu     (enter -1 or CR)
                    1 - Modification of fac  (enter  1)
                    2 - Modification of expo (enter  2)

 Enter your choice


                               **************
                               *            *
                               *   Density  *
                               *            *
                               **************


                         density     =  8.0000000E+02

                -1 - Upper level menu        (enter -1 or CR)
                 1 - Modification of density (enter  1)

 Enter your choice

                             ********************
                             *                  *
                             *   Inertia terms  *
                             *                  *
                             ********************

 Inertia will be neglected in the momentum equations

 Do you agree with this ?
 Enter y(es) or n(o)  (CR=yes)
```

```
               ***************
               *             *
               *   Gravity   *
               *             *
               ***************


gx          =  0.0000000E+00     gy          = -9.8100000E+00
gz          =  0.0000000E+00

        -1 - Upper level menu   (enter -1 or CR)
         1 - Modification of gx (enter  1)
         2 - Modification of gy (enter  2)
         3 - Modification of gz (enter  3)

 Enter your choice

||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

          *******************************
          *                             *
          *   Flow boundary conditions  *
          *                             *
          *******************************


   -1 - Upper level menu                        (enter -1 or CR)
    # - Normal flow rate imposed
    1 - Inflow along boundary  1                (enter  1)
    2 - vx,vy,vz imposed along boundary  2      (enter  2)
    3 - vx,vy,vz imposed along boundary  3      (enter  3)
    4 - vx,vy,vz imposed along boundary  4      (enter  4)
    5 - vx,vy,vz imposed along boundary  5      (enter  5)
    6 - vx,vy,vz imposed along boundary  6      (enter  6)
    7 - vn & vs imposed along boundary  7       (enter  7)
    8 - Outflow along boundary  8               (enter  8)

 Select the boundary condition you want to modify
 1


     ***********************************************
     *                                             *
     *   Flow boundary condition along boundary  1 *
     *                                             *
     ***********************************************

          Current choice : Inflow
                           No force postprocessor

 -2 - Enable force postprocessor                              (enter -2)
 -1 - Upper level menu                                        (enter -1 or
CR)
  # - Interface
  1 - Normal and tangential velocities imposed  (vn & vs)     (enter  1)
  2 - Normal and tangential forces imposed  (fn & fs)         (enter  2)
  3 - Normal velocity and tangential force imposed  (vn & fs) (enter  3)
  4 - Normal force and tangential velocity imposed  (fn & vs) (enter  4)
  5 - Slip conditions                                         (enter  5)
  6 - Plane of symmetry  ( fs=0 & vn=0 )                      (enter  6)
> 7 - Inflow                                                  (enter  7)
  8 - Outflow                                                 (enter  8)
  9 - Free surface                                            (enter  9)
 10 - Global force imposed                                    (enter 10)
 11 - Cartesian velocities imposed  (vx,vy,vz)                (enter 11)

 Enter your choice

7
```

```
                              *****************************
                              *                           *
                              *  Inflow along boundary  1 *
                              *                           *
                              *****************************

 Current value of the volumetric flow rate is  5.2000000E-07
 Enter its new value  (CR=no modification)


                    **********************************************
                    *                                            *
                    *   Flow boundary condition along boundary  2   *
                    *                                            *
                    **********************************************

                         Current choice : vx,vy,vz imposed
                                          No force postprocessor

 -2 - Enable force postprocessor                                      (enter -2)
 -1 - Upper level menu                                                (enter -1 or
CR)
  # - Interface
  1 - Normal and tangential velocities imposed  (vn & vs)             (enter  1)
  2 - Normal and tangential forces imposed  (fn & fs)                 (enter  2)
  3 - Normal velocity and tangential force imposed  (vn & fs)         (enter  3)
  4 - Normal force and tangential velocity imposed  (fn & vs)         (enter  4)
  5 - Slip conditions                                                 (enter  5)
  6 - Plane of symmetry  ( fs=0 & vn=0 )                              (enter  6)
  7 - Inflow                                                          (enter  7)
  8 - Outflow                                                         (enter  8)
  9 - Free surface                                                    (enter  9)
 10 - Global force imposed                                            (enter 10)
>11 - Cartesian velocities imposed  (vx,vy,vz)                        (enter 11)

 Enter your choice

11


                      ****************************************
                      *                                      *
                      *   vx,vy,vz imposed along boundary  2   *
                      *                                      *
                      ****************************************

            The cartesian velocities are expressed as the
            combination of a rotation and of a translation.

          - Coordinates of the 1st point of the rotation axis
              x1 =-1.7505000E-02  y1 = 0.0000000E+00  z1 = 0.0000000E+00
          - Coordinates of the 2nd point of the rotation axis
              x2 =-1.2505000E-02  y2 = 0.0000000E+00  z2 =-1.6470000E-02
          - Angular velocity =  6.2831850E+00
          - Components of the translation velocity
              tx = 0.0000000E+00  ty = 0.0000000E+00  tz = 0.0000000E+00

           -1 - Upper level menu                  (enter -1 or CR)
            1 - Modification of 1st point of the axis (enter  1)
            2 - Modification of 2nd point of the axis (enter  2)
            3 - Modification of angular velocity      (enter  3)
            4 - Modification of translation velocity  (enter  4)

 Enter your choice
```

```
*****************************************
*                                       *
*   vx,vy,vz imposed along boundary  3  *
*                                       *
*****************************************

    The cartesian velocities are expressed as the
    combination of a rotation and of a translation.

  - Coordinates of the 1st point of the rotation axis
     x1 = 0.0000000E+00  y1 = 1.9865000E-02  z1 = 0.0000000E+00
  - Coordinates of the 2nd point of the rotation axis
     x2 = 5.0000000E-03  y2 = 1.9686500E-02  z2 =-1.6470000E-02
  - Angular velocity = -6.2831850E+00
  - Components of the translation velocity
     tx = 0.0000000E+00  ty = 0.0000000E+00  tz = 0.0000000E+00

   -1 - Upper level menu                     (enter -1 or CR)
    1 - Modification of 1st point of the axis (enter  1)
    2 - Modification of 2nd point of the axis (enter  2)
    3 - Modification of angular velocity      (enter  3)
    4 - Modification of translation velocity  (enter  4)

Enter your choice

*****************************************
*                                       *
*   vx,vy,vz imposed along boundary  4  *
*                                       *
*****************************************

    The cartesian velocities are expressed as the
    combination of a rotation and of a translation.

  - Coordinates of the 1st point of the rotation axis
     x1 = 0.0000000E+00  y1 = 1.9865000E-02  z1 = 0.0000000E+00
  - Coordinates of the 2nd point of the rotation axis
     x2 = 5.0000000E-03  y2 = 1.9865000E-02  z2 =-1.6470000E-02
  - Angular velocity = -6.2831850E+00
  - Components of the translation velocity
     tx = 0.0000000E+00  ty = 0.0000000E+00  tz = 0.0000000E+00

   -1 - Upper level menu                     (enter -1 or CR)
    1 - Modification of 1st point of the axis (enter  1)
    2 - Modification of 2nd point of the axis (enter  2)
    3 - Modification of angular velocity      (enter  3)
    4 - Modification of translation velocity  (enter  4)

Enter your choice
```

```
               ****************************************
               *                                      *
               *   vx,vy,vz imposed along boundary  5 *
               *                                      *
               ****************************************

        The cartesian velocities are expressed as the
        combination of a rotation and of a translation.

      - Coordinates of the 1st point of the rotation axis
         x1 = 1.7505000E-02  y1 = 0.0000000E+00  z1 = 0.0000000E+00
      - Coordinates of the 2nd point of the rotation axis
         x2 = 2.2505000E-02  y2 = 0.0000000E+00  z2 =-1.6470000E-02
      - Angular velocity =  6.2831850E+00
      - Components of the translation velocity
         tx = 0.0000000E+00  ty = 0.0000000E+00  tz = 0.0000000E+00

       -1 - Upper level menu                    (enter -1 or CR)
        1 - Modification of 1st point of the axis (enter  1)
        2 - Modification of 2nd point of the axis (enter  2)
        3 - Modification of angular velocity     (enter  3)
        4 - Modification of translation velocity  (enter  4)

Enter your choice


               ****************************************
               *                                      *
               *   vx,vy,vz imposed along boundary  6 *
               *                                      *
               ****************************************

        The cartesian velocities are expressed as the
        combination of a rotation and of a translation.

      - Coordinates of the 1st point of the rotation axis
         x1 = 1.7505000E-02  y1 = 0.0000000E+00  z1 = 0.0000000E+00
      - Coordinates of the 2nd point of the rotation axis
         x2 = 2.2505000E-02  y2 = 0.0000000E+00  z2 =-1.6470000E-02
      - Angular velocity =  6.2831850E+00
      - Components of the translation velocity
         tx = 0.0000000E+00  ty = 0.0000000E+00  tz = 0.0000000E+00

       -1 - Upper level menu                    (enter -1 or CR)
        1 - Modification of 1st point of the axis (enter  1)
        2 - Modification of 2nd point of the axis (enter  2)
        3 - Modification of angular velocity     (enter  3)
        4 - Modification of translation velocity  (enter  4)

Enter your choice
```

```
***********************************************
*                                             *
*   Flow boundary condition along boundary  7 *
*                                             *
***********************************************

         Current choice : vn & vs imposed
                          No force postprocessor

 -2 - Enable force postprocessor                                      (enter -2)
 -1 - Upper level menu                                                (enter -1 or
CR)
  # - Interface
> 1 - Normal and tangential velocities imposed  (vn & vs)             (enter  1)
  2 - Normal and tangential forces imposed  (fn & fs)                 (enter  2)
  3 - Normal velocity and tangential force imposed  (vn & fs)         (enter  3)
  4 - Normal force and tangential velocity imposed  (fn & vs)         (enter  4)
  5 - Slip conditions                                                 (enter  5)
  6 - Plane of symmetry  ( fs=0 & vn=0 )                              (enter  6)
  7 - Inflow                                                          (enter  7)
  8 - Outflow                                                         (enter  8)
  9 - Free surface                                                    (enter  9)
 10 - Global force imposed                                            (enter 10)
 11 - Cartesian velocities imposed  (vx,vy,vz)                        (enter 11)

 Enter your choice
1

       ***************************************
       *                                     *
       *   vn & vs imposed along boundary  7 *
       *                                     *
       ***************************************

          -   vn  : constant =  0.0000000E+00

    -1 - Upper level menu                  (enter -1 or CR)
     1 - Constant                          (enter  1)
     2 - Linear function of coordinates    (enter  2)

 Enter your choice

       ***************************************
       *                                     *
       *   vn & vs imposed along boundary  7 *
       *                                     *
       ***************************************

          -   vs  : constant =  0.0000000E+00

    -1 - Upper level menu                  (enter -1 or CR)
     # - Constant
     # - Linear function of coordinates

 Enter your choice
```

```
          ******************************************
          *                                        *
          *   Flow boundary condition along boundary  8   *
          *                                        *
          ******************************************

               Current choice : Outflow
                                No force postprocessor

 -2 - Enable force postprocessor                                  (enter -2)
 -1 - Upper level menu                                            (enter -1 or
CR)
  # - Interface
  1 - Normal and tangential velocities imposed  (vn & vs)         (enter  1)
  2 - Normal and tangential forces imposed  (fn & fs)             (enter  2)
  3 - Normal velocity and tangential force imposed  (vn & fs)     (enter  3)
  4 - Normal force and tangential velocity imposed  (fn & vs)     (enter  4)
  5 - Slip conditions                                             (enter  5)
  6 - Plane of symmetry  ( fs=0 & vn=0 )                          (enter  6)
  7 - Inflow                                                      (enter  7)
> 8 - Outflow                                                     (enter  8)
  9 - Free surface                                                (enter  9)
 10 - Global force imposed                                        (enter 10)
 11 - Cartesian velocities imposed  (vx,vy,vz)                    (enter 11)

 Enter your choice
8


                    *******************************
                    *                             *
                    *   Outflow along boundary  8   *
                    *                             *
                    *******************************

 Zero normal force imposed

  Do you agree with this ?
 Enter y(es) or n(o)  (CR=yes)
```

```
                    ********************
                    *                  *
                    *   Interpolation  *
                    *                  *
                    ********************

  Current setup : Linear coordinates
                  Quadratic velocities, linear pressure
                  Picard iterations on viscosity(g)
                  No upwinding in momentum equations

   -1 - Upper level menu                                         (enter -1 or
CR)
    1 - Quadratic coordinates                                    (enter  1)
    # - Quadratic element for stresses
    # - 4x4 SU element for stresses
    # - 4x4 SUPG element for stresses
    # - EVSS for stresses
    # - EVSS SU for stresses
    # - EVSS SUPG for stresses
    8 - Quadratic velocities, linear pressure                    (enter  8)
    9 - Mini-element for velocities, constant pressure           (enter  9)
   10 - Linear velocities, constant pressure                     (enter 10)
   11 - Quadratic velocities, linear discontinuous pressure      (enter 11)
   12 - Newton iterations on viscosity(g)                        (enter 12)
    # - Linear    element for temperature
    # - Quadratic element for temperature
    # - 2x2       element for temperature
    # - 4x4       element for temperature
    # - Upwinding in momentum equations
    # - Sub-interpolation

 Enter your choice

||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

                  ***********************
                  *                     *
                  *   Local shear-rate  *
                  *                     *
                  ***********************


          -1 - Upper level menu                (enter -1)
           1 - Local shear-rate                (enter  1 or CR)
           2 - Viscosity                       (enter  2)
           3 - Rate of deformation tensor      (enter  3)
           4 - Inelastic stress tensor         (enter  4)
           5 - Viscous heating                 (enter  5)
           # - Total extra-stress tensor
           7 - Residence time                  (enter  7)
           # - Tracking of material points
           9 - Tracking of a material property (enter  9)
          10 - Forces on slices                (enter 10)

 Enter your choice


 The calculation will be done on S1.

 Hit CR to continue
```

```
                    ******************************
                    *                            *
                    *   Inelastic stress tensor  *
                    *                            *
                    ******************************

   -1 - Upper level menu                      (enter -1)
    1 - Local shear-rate                      (enter  1)
    2 - Viscosity                             (enter  2)
    3 - Rate of deformation tensor            (enter  3)
    4 - Inelastic stress tensor               (enter  4 or CR)
    5 - Viscous heating                       (enter  5)
    # - Total extra-stress tensor
    7 - Residence time                        (enter  7)
    # - Tracking of material points
    9 - Tracking of a material property       (enter  9)
   10 - Forces on slices                      (enter 10)

Enter your choice


The calculation will be done on S1.

Hit CR to continue

                       ************************
                       *                      *
                       *   Mixing efficiency  *
                       *                      *
                       ************************

   -1 - Upper level menu                      (enter -1)
    1 - Local shear-rate                      (enter  1 or CR)
    2 - Viscosity                             (enter  2)
    3 - Rate of deformation tensor            (enter  3)
    4 - Inelastic stress tensor               (enter  4)
    5 - Viscous heating                       (enter  5)
    # - Total extra-stress tensor
    7 - Residence time                        (enter  7)
    # - Tracking of material points
    9 - Tracking of a material property       (enter  9)
   10 - Forces on slices                      (enter 10)

Enter your choice


The calculation will be done on S1.

Hit CR to continue
```

APPENDIX 5

All CICo-TSE Mixing Zones - 2D Steady State Simulations

2D trilobal element and mixing disc zone simulations were represented using the following parameters.

Name of Mesh File:

2d*te.msh * = 0° - 30° in 5° rotations (Trilobe elements)

2d*md.msh * = 0° - 30° in 5° rotations (Mixing discs)

Name of Data File:

2d*A60m2B.dat

where,

A = te or md used to represent either the trilobe element or mixing disc zones respectively.

B = If the problem contained non-slip boundaries then the suffix ns was used. For problems possessing slip boundaries, then the suffixes p1, p2, ... were used instead to represent the different degrees of slippage.

New Task:

1 **Task 1:**

Method of Solving Problem:

F.E.M. task

Steady-state

Geometry:

2D planar geometry

Create a Sub-Task:

A **Sub-Task 1:**

Problem to be Solved:

Generalized Newtonian isothermal flow problem

Title Given to Sub-Task 1:

1. Rotation

B Sub-Task 2 - 4:

Problem to be Solved:

Post-Processor

Titles Given to Sub-Task 2 - 8:

2. Local shear-rate (& average value)
3. Inelastic stress tensor (& average value)
4. Mixing efficiency (& average value)

Domain of the Sub-Tasks:

Over whole mesh

Material Data (Ideal Rheology for Polypropylene):

1 Shear-Rate Dependence of Viscosity:

Power Law (f(g) is a function of shear rate):

f(g) = fac*g**(expo-1)

Shear Rate Viscosity (poise):	fac = 4400
Power Index:	expo = 0.5

5 Density:

Density (kg m^{-3}): r0 = 800

6 Inertia Terms:

Inertia will be neglected in the momentum equations:

11 Gravity:

Gravity component (m sec^{-2}) $g_x = 0$ and $g_y = -9.81$

The $g_y = -9.81$ value is not taken into account within momentum equations, as only volumetric gravity force is considered within Polyflow.

Flow Boundary Conditions:

Boundary Number to Which Conditions Apply:

BS1: Left Hand Element (rotating counter-clockwise at 1 revolution per second).

11 Cartesian Velocities Imposed (v_x, v_y):

Coordinates of rotational centre (m): $x = -0.017505$ and $y = 0$

Angular velocity (rad sec^{-1}) : $v = 2\pi$

(Positive value indicates counter-clockwise direction).

Components of translation velocity (m sec^{-1}): $t_x = 0$ and $t_y = 0$

Boundary Number to Which Conditions Apply:

BS2: Right Hand Element (rotating counter-clockwise at 1 revolution per second).

11 Cartesian Velocities Imposed (v_x, v_y):

Coordinates of rotational centre (m): $x = 0.017505$, $y = 0$

Angular velocity (rad sec^{-1}) : $v = 2\pi$

(Positive value indicates counter-clockwise direction).

Components of translation velocity (m sec^{-1}): $t_x = 0$ and $t_y = 0$

Boundary Number to Which Conditions Apply:

BS3: Outer Figure-of-Eight Barrel (non-slip boundary)

1 Normal & Tangential Velocities Imposed (v_n & v_s):

Normal velocity component (m sec^{-1}): $v_n = 0$

Tangential velocity component (m sec^{-1}): $v_s = 0$

For the 2D slip problems, v_s was assigned the following values to represent different values of slippage:

$v_s = 0.25\ (2\pi r)$

$v_s = 0.50\ (2\pi r)$

$v_s = 0.75\ (2\pi r)$

Full slip was assumed to be the value $v_s = 2\pi r$. For all calculations $r = 0.020075$ m, where r is the distance between the center of each element and the outer barrel surface.

Interpolation:

Linear coordinates

Quadratic velocities, linear pressure

Picard iterations on viscosity(g)

No upwinding in momentum equations

Numerical Parameters:

No previous solution

Maximum number of iterations	= 50
Convergence test	= 1×10^{-8}
Divergence test	= 1×10^{3}

Coupled iterations for moving boundaries

Surface kinematic condition

Assign the Pressure:

The pressure field is currently imposed at the node closest to the coordinates: x = 0 and y = 0

Current value of the pressure condition is: P = 0 (Pa)

Assign the Stream Function:

The stream function currently vanishes at the node closest to the coordinates: x = 0 and y = 0

Mesh to Mesh Interpolation

None

Outputs

Current output(s):	CFView-PF
Listing:	max
Check ADDR:	off

Appendix K:

Flow Problem Parameters as Seen Within Each Polydata Menu, for the Steady State Simulation of all 2D Mixing Zones.

```
                    **********************
                    *                    *
                    *   P O L Y D A T A  *
                    *                    *
                    **********************

                 Version :  3.  4.  6.    1

     # - Save and exit
     1 - Read a mesh file                        (enter  1 or CR)
     2 - Read and optimize a mesh file           (enter  2)
     3 - Convert a mesh file                     (enter  3)
     4 - Filename syntax                         (enter  4)
     # - Outputs
     # - Read an old data file
     # - Create a new task
     # - Redefine global parameters of a task

 Enter your choice


 Enter the name of the mesh file (default = msh)

2d0se.msh

 Is it a formatted file
 Enter y(es) or n(o)  (CR=yes)

Loading the mesh data...

                    **********************
                    *                    *
                    *   P O L Y D A T A  *
                    *                    *
                    **********************

                 Version :  3.  4.  6.    1

     # - Save and exit
     # - Read a mesh file
     # - Read and optimize a mesh file
     3 - Convert a mesh file                     (enter  3)
     4 - Filename syntax                         (enter  4)
     # - Outputs
     6 - Read an old data file                   (enter  6)
     7 - Create a new task                       (enter  7 or CR)
     # - Redefine global parameters of a task

 Enter your choice

6

 Enter the name of the old data file (default = dat)

2d0se60m2nsa.dat

Loading the data...

Checking the data...
```

```
                    ************************
                    *                      *
                    *   P O L Y D A T A    *
                    *                      *
                    ************************

                  Version :  3.  4.  6.   1

      0 - Save and exit                              (enter  0)
      # - Read a mesh file
      # - Read and optimize a mesh file
      3 - Convert a mesh file                        (enter  3)
      4 - Filename syntax                            (enter  4)
      5 - Outputs                                    (enter  5)
      # - Read an old data file
      7 - Create a new task                          (enter  7)
      8 - Redefine global parameters of a task       (enter  8)
      9 - F.E.M. Task  1                             (enter  9)

 Enter your choice

5

||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

                        ***************
                        *             *
                        *   Outputs   *
                        *             *
                        ***************

                Current output(s) : CFView-PF
                Listing           : max
                Check ADDR        : off

          -1 - Upper level menu          (enter -1 or CR)
           # - Output Triggering
           1 - Enable Polyplot output    (enter  1)
           2 - Enable Patran output      (enter  2)
           3 - Enable Supertab output    (enter  3)
           4 - Enable DataVisual output  (enter  4)
           # - Enable Explorer output
           6 - Disable CFView-PF output  (enter  6)
           7 - Enable Polyflow output    (enter  7)
           8 - Listing    : none         (enter  8)
           9 - Listing    : min          (enter  9)
          10 - Listing    : max          (enter 10)
          11 - Enable  ADDR check        (enter 11)

 Enter your choice
```

```
                    *******************************************
                    *                                         *
                    *    Redefine global parameters of a task  *
                    *                                         *
                    *******************************************

                        Current setup : - F.E.M. task
                                        - Steady-state
                                        - 2D planar geometry

                 -2 - Delete the current task        (enter -2)
                 -1 - Accept the current setup       (enter -1 or CR)
               >  1 - F.E.M. task                    (enter  1)
                  # - MIXING task
               >  3 - Steady-state problem(s)        (enter  3)
                  4 - Time-dependent problem(s)      (enter  4)
                  5 - Evolution problem(s)           (enter  5)
                  6 - Rigid rotation                 (enter  6)
               >  7 - 2D planar geometry             (enter  7)
                  # - 2D axisymmetric geometry
                  9 - 2D 1/2 planar geometry         (enter  9)
                  # - 2D 1/2 axisymmetric geometry

 Enter your choice


||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

                              *********************
                              *                   *
                              *   F.E.M. Task  1  *
                              *                   *
                              *********************


          -1 - Upper level menu                                 (enter -1 or CR)
           1 - Numerical parameters                             (enter  1)
           2 - Create a sub-task                                (enter  2)
           3 - Redefine global parameters of a sub-task         (enter  3)
           4 - Assign the pressure                              (enter  4)
           5 - Assign the stream function                       (enter  5)
           6 - Mesh-mesh interpolation                          (enter  6)
           # - Define species
           # - Define reactions
           9 - Rotation                                         (enter  9)
          10 - Local shear-rate                                 (enter 10)
          11 - Inelastic stress tensor                          (enter 11)
          12 - Mixing efficiency                                (enter 12)

 Enter your choice

1
```

```
                    *****************************
                    *                           *
                    *   Numerical parameters    *
                    *                           *
                    *****************************

      - No previous solution
      - Maximum number of iterations                    =      50
      - Convergence test                                =    1.0000000E-08
      - Divergence test                                 =    1.0000000E+03
      - Coupled iterations for moving bound.
      - Surface kinematic condition

  -1 - Upper level menu                                    (enter -1 or CR)
   1 - Start with an old result file                       (enter  1)
   2 - Modify the max number of iterations                 (enter  2)
   3 - Modify the convergence test                         (enter  3)
   4 - Modify the divergence test                          (enter  4)
   5 - Decoupled iterations for moving bound.              (enter  5)
   # - Modify the max number of 'fixed' iterations
   # - Modify the convergence test ('fixed' iterations)
   # - Line kinematic condition

 Enter your choice


                    ***************************
                    *                         *
                    *   Assign the pressure   *
                    *                         *
                    ***************************

         The calculation of the pressure field associated
        with the following velocity field requires a point at
        which the value of the pressure is imposed.

         1 : Field of sub-task Rotation

        -1 - Upper level menu                (enter -1 or CR)
         1 - Pressure condition for field  1 (enter  1)

 Enter your choice

1

                    **************************
                    *                        *
                    *   Pressure condition   *
                    *                        *
                    **************************

  The pressure field is currently imposed at the node
 closest to coordinates :

              X = 0.0000000E+00  Y = 0.0000000E+00

 Do you agree with this ?
 Enter y(es) or n(o)  (CR=yes)

 Current value of pressure condition is 0.0000000E+00
 Enter its new value  (CR=no modification)
```

```
                    **********************************
                    *                                *
                    *   Assign the stream function   *
                    *                                *
                    **********************************

            The calculation of the stream function PSI associated
           with the following velocity or Darcy pressure field
           requires a point at which PSI equals to zero.

            1 : Field of sub-task Rotation

      -1 - Upper level menu                               (enter -1 or CR)
       1 - Condition on the stream function for field  1 (enter  1)

  Enter your choice

 1

                 ****************************************
                 *                                      *
                 *   Condition on the stream function   *
                 *                                      *
                 ****************************************

  The stream function currently vanishes at the node
 closest to coordinates :

             X = 0.0000000E+00  Y = 0.0000000E+00

 Do you agree with this ?
 Enter y(es) or n(o)  (CR=yes)

                      ******************************
                      *                            *
                      *   Mesh-mesh interpolation  *
                      *                            *
                      ******************************

             Mesh-mesh interpolations interpolate all potential
             velocity, pressure, temperature, and stress fields
             from a previous result to the current task.

             Such an interpolation has not yet been defined.

                 -1 - Accept current setup  (enter -1 or CR)
                  1 - Create interpolations (enter  1)
                  # - Modify file names

 Enter your choice

            ***********************************************
            *                                             *
            *   Redefine global parameters of a sub-task  *
            *                                             *
            ***********************************************

                            Sub-task : Rotation

         -1 - Upper level menu                           (enter -1 or CR)
          1 - Delete the current sub-task                (enter  1)
          2 - Modify the title of the current sub-task   (enter  2)
          3 - Modify the type of the current sub-task    (enter  3)

 Enter your choice

3
```

```
**************************************************
*                                                *
*   Redefine global parameters of a sub-task     *
*                                                *
**************************************************


 > 1 - Generalized Newtonian isothermal flow problem          (enter  1 or
CR)
   2 - Generalized Newtonian non-isothermal flow problem      (enter  2)
   3 - Heat conduction problem                                (enter  3)
   4 - Differential viscoelastic isothermal flow problem      (enter  4)
   5 - Differential viscoelastic non-isothermal flow problem  (enter  5)
   # - Postprocessor
   7 - Integral viscoelastic isothermal flow problem          (enter  7)
   8 - Integral viscoelastic non-isothermal flow problem      (enter  8)
   9 - Darcy isothermal flow problem                          (enter  9)
  10 - Darcy non-isothermal flow problem                      (enter 10)
  11 - Slightly compressible flow problem                     (enter 11)
   # - Mass transfer problem
  13 - Potential problem                                      (enter 13)
  14 - Film model : Gen. Newtonian isothermal                 (enter 14)
  15 - Film model : Gen. Newtonian non-isothermal             (enter 15)
  16 - Film model : Viscoelastic isothermal                   (enter 16)
   # - Thickness for film
   # - Transport of species
   # - Closure

 Enter your choice


||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||


                 ****************
                 *              *
                 *   Rotation   *
                 *              *
                 ****************


        -1 - Upper level menu          (enter -1 or CR)
         1 - Domain of the sub-task    (enter  1)
         2 - Material data             (enter  2)
         3 - Flow boundary conditions  (enter  3)
         # - Global remeshing
         # - Rigid translation
         6 - Interpolation             (enter  6)
         # - Bubbling

 Enter your choice
1
              ******************************
              *                            *
              *   Domain of the sub-task   *
              *                            *
              ******************************

        The current sub-task is defined on : whole mesh

       -2 - Make the current domain empty (enter -2)
       -1 - Upper level menu              (enter -1 or CR)
        # - Extension to the whole mesh
        1 - Removal of subdomain  1       (enter  1)

 Enter your choice
```

```
                    *********************
                    *                   *
                    *   Material data   *
                    *                   *
                    *********************

   -1 - Upper level menu                        (enter -1 or CR)
    1 - Shear-rate dependence of viscosity      (enter  1)
    # - Temperature dependence of viscosity
    # - Differential viscoelastic models
    # - Integral Viscoelastic models
    5 - Density                                 (enter  5)
    6 - Inertia terms                           (enter  6)
    # - Coefficient of thermal expansion
    # - Thermal conductivity
    # - Heat capacity per unit mass
    # - Viscous heating
   11 - Gravity                                 (enter 11)
    # - Average temperature
    # - Heat source per unit volume

 Enter your choice

1

            ******************************************
            *                                        *
            *   Shear-rate dependence of viscosity   *
            *                                        *
            ******************************************


             -1 - Upper level menu     (enter -1 or CR)
              1 - Constant viscosity   (enter  1)
              2 - Bird-Carreau law     (enter  2)
            > 3 - Power law            (enter  3)
              4 - Bingham law          (enter  4)
              5 - Herschel-Bulkley law (enter  5)
              6 - Cross law            (enter  6)

 Enter your choice

3

                       *****************
                       *               *
                       *   Power law   *
                       *               *
                       *****************

                       f(g) = fac * g**(expo-1)

       fac          =  4.4000000E+03      expo         =  5.0000000E-01

             -1 - Upper level menu     (enter -1 or CR)
              1 - Modification of fac  (enter  1)
              2 - Modification of expo (enter  2)

 Enter your choice
```

```
***************
*             *
*   Density   *
*             *
***************


density      =  8.0000000E+02

-1 - Upper level menu         (enter -1 or CR)
 1 - Modification of density (enter  1)

Enter your choice

*********************
*                   *
*   Inertia terms   *
*                   *
*********************

Inertia will be neglected in the momentum equations

Do you agree with this ?
Enter y(es) or n(o)  (CR=yes)


***************
*             *
*   Gravity   *
*             *
***************


gx           =  0.0000000E+00      gy           = -9.8100000E+00
gz           =  0.0000000E+00

-1 - Upper level menu   (enter -1 or CR)
 1 - Modification of gx (enter  1)
 2 - Modification of gy (enter  2)
 # - Modification of gz

Enter your choice


||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||


********************************
*                              *
*   Flow boundary conditions   *
*                              *
********************************


-1 - Upper level menu                          (enter -1 or CR)
 # - Normal flow rate imposed
 1 - vx,vy imposed along boundary  1    (enter  1)
 2 - vx,vy imposed along boundary  2    (enter  2)
 3 - vn & vs imposed along boundary  3 (enter  3)

Select the boundary condition you want to modify

1
```

```
                **************************************************
                *                                                *
                *    Flow boundary condition along boundary  1   *
                *                                                *
                **************************************************

                     Current choice : vx,vy imposed
                                      No force postprocessor

 -2 - Enable force postprocessor                                 (enter -2)
 -1 - Upper level menu                                           (enter -1 or
CR)
  # - Interface
  1 - Normal and tangential velocities imposed  (vn & vs)        (enter  1)
  2 - Normal and tangential forces imposed  (fn & fs)            (enter  2)
  3 - Normal velocity and tangential force imposed  (vn & fs)    (enter  3)
  4 - Normal force and tangential velocity imposed  (fn & vs)    (enter  4)
  5 - Slip conditions                                            (enter  5)
  6 - Plane of symmetry  ( fs=0 & vn=0 )                         (enter  6)
  7 - Inflow                                                     (enter  7)
  8 - Outflow                                                    (enter  8)
  9 - Free surface                                               (enter  9)
 10 - Global force imposed                                       (enter 10)
>11 - Cartesian velocities imposed  (vx,vy)                      (enter 11)

 Enter your choice

11

                     ***************************************
                     *                                     *
                     *   vx,vy imposed along boundary  1   *
                     *                                     *
                     ***************************************

                 The cartesian velocities are expressed as the
                 combination of a rotation and of a translation.

               - Coordinates of the rotation center
                  x =-1.7505000E-02  y = 0.0000000E+00
               - Angular velocity =  6.2831850E+00
               - Components of the translation velocity
                  tx = 0.0000000E+00  ty = 0.0000000E+00

          -1 - Upper level menu                        (enter -1 or CR)
           1 - Modification of the rotation center     (enter  1)
           2 - Modification of angular velocity        (enter  2)
           3 - Modification of translation velocity    (enter  3)

 Enter your choice
```

```
            ****************************************
            *                                      *
            *   vx,vy imposed along boundary  2    *
            *                                      *
            ****************************************

         The cartesian velocities are expressed as the
         combination of a rotation and of a translation.

       - Coordinates of the rotation center
           x = 1.7505000E-02  y = 0.0000000E+00
       - Angular velocity =  6.2831850E+00
       - Components of the translation velocity
           tx = 0.0000000E+00  ty = 0.0000000E+00

   -1 - Upper level menu                       (enter -1 or CR)
    1 - Modification of the rotation center    (enter  1)
    2 - Modification of angular velocity       (enter  2)
    3 - Modification of translation velocity   (enter  3)

 Enter your choice


        ************************************************
        *                                              *
        *   Flow boundary condition along boundary  3  *
        *                                              *
        ************************************************

             Current choice : vn & vs imposed
                              No force postprocessor

 -2 - Enable force postprocessor                              (enter -2)
 -1 - Upper level menu                                        (enter -1 or
CR)
  # - Interface
> 1 - Normal and tangential velocities imposed  (vn & vs)     (enter  1)
  2 - Normal and tangential forces imposed  (fn & fs)         (enter  2)
  3 - Normal velocity and tangential force imposed  (vn & fs) (enter  3)
  4 - Normal force and tangential velocity imposed  (fn & vs) (enter  4)
  5 - Slip conditions                                         (enter  5)
  6 - Plane of symmetry  ( fs=0 & vn=0 )                      (enter  6)
  7 - Inflow                                                  (enter  7)
  8 - Outflow                                                 (enter  8)
  9 - Free surface                                            (enter  9)
 10 - Global force imposed                                    (enter 10)
 11 - Cartesian velocities imposed  (vx,vy)                   (enter 11)

 Enter your choice

1


           ****************************************
           *                                      *
           *   vn & vs imposed along boundary  3  *
           *                                      *
           ****************************************

              -   vn : constant =  0.0000000E+00

      -1 - Upper level menu                    (enter -1 or CR)
       1 - Constant                            (enter  1)
       2 - Linear function of coordinates      (enter  2)

 Enter your choice
```

```
*****************************************
*                                       *
*   vn & vs imposed along boundary  3   *
*                                       *
*****************************************

   -   vs  : constant =  0.0000000E+00

 -1 - Upper level menu                  (enter -1 or CR)
  1 - Constant                          (enter  1)
  2 - Linear function of coordinates    (enter  2)

Enter your choice
```

||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

```
********************
*                  *
*   Interpolation  *
*                  *
********************

Current setup : Linear coordinates
                Quadratic velocities, linear pressure
                Picard iterations on viscosity(g)
                No upwinding in momentum equations

  -1 - Upper level menu                                   (enter -1 or
CR)
   1 - Quadratic coordinates                              (enter  1)
   # - Quadratic element for stresses
   # - 4x4 SU element for stresses
   # - 4x4 SUPG element for stresses
   # - EVSS for stresses
   # - EVSS SU for stresses
   # - EVSS SUPG for stresses
   8 - Quadratic velocities, linear pressure              (enter  8)
   # - Mini-element for velocities, constant pressure
  10 - Linear velocities, constant pressure               (enter 10)
  11 - Quadratic velocities, linear discontinuous pressure (enter 11)
  12 - Newton iterations on viscosity(g)                  (enter 12)
   # - Linear    element for temperature
   # - Quadratic element for temperature
   # - 2x2       element for temperature
   # - 4x4       element for temperature
   # - Upwinding in momentum equations
   # - Sub-interpolation

Enter your choice
```

```
                    ************************
                    *                      *
                    *   Local shear-rate   *
                    *                      *
                    ************************


  -1 - Upper level menu                 (enter -1)
   1 - Local shear-rate                 (enter  1 or CR)
   2 - Viscosity                        (enter  2)
   3 - Rate of deformation tensor       (enter  3)
   4 - Inelastic stress tensor          (enter  4)
   5 - Viscous heating                  (enter  5)
   # - Total extra-stress tensor
   7 - Residence time                   (enter  7)
   # - Tracking of material points
   9 - Tracking of a material property  (enter  9)
  10 - Forces on slices                 (enter 10)

Enter your choice

The calculation will be done on S1.

Hit CR to continue

                 ******************************
                 *                            *
                 *   Inelastic stress tensor  *
                 *                            *
                 ******************************


  -1 - Upper level menu                 (enter -1)
   1 - Local shear-rate                 (enter  1)
   2 - Viscosity                        (enter  2)
   3 - Rate of deformation tensor       (enter  3)
   4 - Inelastic stress tensor          (enter  4 or CR)
   5 - Viscous heating                  (enter  5)
   # - Total extra-stress tensor
   7 - Residence time                   (enter  7)
   # - Tracking of material points
   9 - Tracking of a material property  (enter  9)
  10 - Forces on slices                 (enter 10)

Enter your choice


The calculation will be done on S1.

Hit CR to continue
```

```
*************************
*                       *
*   Mixing efficiency   *
*                       *
*************************


 -1 - Upper level menu                      (enter -1)
  1 - Local shear-rate                      (enter  1 or CR)
  2 - Viscosity                             (enter  2)
  3 - Rate of deformation tensor            (enter  3)
  4 - Inelastic stress tensor               (enter  4)
  5 - Viscous heating                       (enter  5)
  # - Total extra-stress tensor
  7 - Residence time                        (enter  7)
  # - Tracking of material points
  9 - Tracking of a material property       (enter  9)
 10 - Forces on slices                      (enter 10)

Enter your choice


The calculation will be done on S1.

Hit CR to continue
```

APPENDIX L

All CICo-TSE Mixing Zones - 3D Steady State Simulations

3D trilobal element and mixing disc zone simulations were represented using the following parameters.

Name of Mesh File:

3d*te.msh	* = 0° - 30° in 15° rotations	(Trilobe elements)
3d*md.msh	* = 0° - 30° in 15° rotations	(Staggered Mixing discs)

Name of Data File:

2d*A60m2ns.dat

where,

A = te or md used to represent either the trilobe element or mixing disc zones respectively.

New Task:

1 **Task 1:**

Method of Solving Problem:

F.E.M. task

Steady-state

Create a Sub-Task:

A **Sub-Task 1:**

Problem to be Solved:

Generalized Newtonian isothermal flow problem

Title Given to Sub-Task 1:

1 3D Rotation

B **Sub-Task 2 - 5:**

Problem to be Solved:

Post-Processor

Titles Given to Sub-Task 2 - 8:

2 Local shear-rate (& average value)

3 Inelastic stress tensor (& average value)

4 Mixing efficiency (& average value)

5 Outflow (through outlet BS5)

Domain of the Sub-Tasks:

Over whole mesh

Material Data (Ideal Rheology for Polypropylene):

1 Shear-Rate Dependence of Viscosity:

Power Law (f(g) is a function of shear rate):

f(g) = fac*g**(expo-1)

Shear Rate Viscosity (poise):	fac = 4400
Power Index:	expo = 0.5

5 Density:

Density (kg m^{-3}): r0 = 800

6 Inertia Terms:

Inertia will be neglected in the momentum equations:

11 Gravity:

Gravity component (m sec^{-2}) $g_x = 0$, $g_y = -9.81$ and $g_z = 0$

The $g_y = -9.81$ value is not taken into account within momentum equations, as only volumetric gravity force is considered within Polyflow.

Flow Boundary Conditions:

Boundary Number to Which Conditions Apply:

BS1: Inlet

6 Inflow

Volumetric flow rate (m^3 sec^{-1}) $= 5.20 \times 10^{-7}$

Boundary Number to Which Conditions Apply:

BS2: Left Hand Element (rotating counter-clockwise at 1 revolution per second).

11 Cartesian Velocities Imposed (v_x, v_y):

Coordinates of 1st rotation centre (m): x = -0.017505, y = 0 and z = 0

Coordinates of 2nd rotation centre (m): $x = -0.017505$, $y = 0$ and $z = Z$

(where Z represents the coordinates of the end of the respective TSE element)

Angular velocity (rad sec^{-1}) : $v = -2\pi$

(Negative value indicates counter-clockwise direction).

Components of translation velocity (m sec^{-1}): $t_x = 0$, $t_y = 0$ and $t_z = 0$

Boundary Number to Which Conditions Apply:

BS3: Right Hand Element (rotating counter-clockwise at 1 revolution per second).

11 Cartesian Velocities Imposed (v_x, v_y):

Coordinates of 1st rotation centre (m): $x = 0.017505$, $y = 0$ and $z = 0$

Coordinates of 2nd rotation centre (m): $x = 0.017505$, $y = 0$ and $z = Z$

(where Z represents the coordinates of the end of the respective TSE element)

Angular velocity (rad sec^{-1}) : $v = -2\pi$

(Negative value indicates counter-clockwise direction).

Components of translation velocity (m sec^{-1}): $t_x = 0$, $t_y = 0$ and $t_z = 0$

Boundary Number to Which Conditions Apply:

BS4: Outer Figure-of-Eight Barrel (non-slip boundary).

1 Normal & Tangential Velocities Imposed (v_n & v_s):

Normal velocity component (m sec^{-1}): $v_n = 0$

Tangential velocity component (m sec^{-1}): $v_s = 0$

Boundary Number to Which Conditions Apply:

BS5: Outlet.

7 Outflow

Zero normal derivative on velocity imposed

Interpolation:

Linear coordinates

Quadratic velocities, linear pressure

Picard iterations on viscosity(g)

No upwinding in momentum equations

Numerical Parameters:

No previous solution

Maximum number of iterations = 50 for SGI calculations.

	= 20 for CRAY J90 calculations.
Convergence test	= 1×10^{-8} for SGI calculations.
	= 1×10^{-3} for CRAY J90 calculations.
Divergence test	= 1×10^{4}

Coupled iterations for moving boundaries

Surface kinematic condition

Assign the Pressure:

Pressure field is currently imposed at the node closest to the coordinates: $x = 0$, $y = 0$ and $z = 0$

Current value of the pressure condition is: $P = 1 \times 10^{5}$ (Pa)

Mesh to Mesh Interpolation

None

Outputs

Current output(s):	CFView-PF
Listing:	max
Check ADDR:	off

Appendix M:

Flow Problem Parameters as Seen Within Each Polydata Menu, for the Steady State Simulation of all 3D Mixing Zones.

```
                    ***********************
                    *                     *
                    *   P O L Y D A T A   *
                    *                     *
                    ***********************

                  Version :  3.  4.  6.    1

     # - Save and exit
     1 - Read a mesh file                        (enter  1 or CR)
     2 - Read and optimize a mesh file           (enter  2)
     3 - Convert a mesh file                     (enter  3)
     4 - Filename syntax                         (enter  4)
     # - Outputs
     # - Read an old data file
     # - Create a new task
     # - Redefine global parameters of a task

 Enter your choice


 Enter the name of the mesh file (default = msh)

te3d15x2.msh

 Is it a formatted file
 Enter y(es) or n(o)  (CR=yes)

 Loading the mesh data ...

                    ***********************
                    *                     *
                    *   P O L Y D A T A   *
                    *                     *
                    ***********************

                  Version :  3.  4.  6.    1

     # - Save and exit
     # - Read a mesh file
     # - Read and optimize a mesh file
     3 - Convert a mesh file                     (enter  3)
     4 - Filename syntax                         (enter  4)
     # - Outputs
     6 - Read an old data file                   (enter  6)
     7 - Create a new task                       (enter  7 or CR)
     # - Redefine global parameters of a task

 Enter your choice

6

 Enter the name of the old data file (default = dat)

60m2nsa.dat

 Loading the data ...

 Checking the data ...
```

```
                        ***********************
                        *                     *
                        *   P O L Y D A T A   *
                        *                     *
                        ***********************

                      Version :  3.  4.  6.    1

       0 - Save and exit                            (enter  0)
       # - Read a mesh file
       # - Read and optimize a mesh file
       3 - Convert a mesh file                      (enter  3)
       4 - Filename syntax                          (enter  4)
       5 - Outputs                                  (enter  5)
       # - Read an old data file
       7 - Create a new task                        (enter  7)
       8 - Redefine global parameters of a task     (enter  8)
       9 - F.E.M. Task  1                           (enter  9)

 Enter your choice
5

||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

                          ***************
                          *             *
                          *   Outputs   *
                          *             *
                          ***************

                     Current output(s) : CFView-PF
                     Listing           : max
                     Check ADDR        : off

          -1 - Upper level menu          (enter -1 or CR)
           # - Output Triggering
           1 - Enable 3DCross output     (enter  1)
           2 - Enable Patran output      (enter  2)
           3 - Enable Supertab output    (enter  3)
           4 - Enable DataVisual output  (enter  4)
           # - Enable Explorer output
           6 - Disable CFView-PF output  (enter  6)
           7 - Enable Polyflow output    (enter  7)
           8 - Listing   : none          (enter  8)
           9 - Listing   : min           (enter  9)
          10 - Listing   : max           (enter 10)
          11 - Enable  ADDR check        (enter 11)

 Enter your choice
```

```
*******************************************
*                                         *
*   Redefine global parameters of a task  *
*                                         *
*******************************************

        Current setup : - F.E.M. task
                        - Steady-state

 -2 - Delete the current task   (enter -2)
 -1 - Accept the current setup  (enter -1 or CR)
> 1 - F.E.M. task               (enter  1)
  # - MIXING task
> 3 - Steady-state problem(s)   (enter  3)
  4 - Time-dependent problem(s) (enter  4)
  5 - Evolution problem(s)      (enter  5)
  6 - Rigid rotation            (enter  6)

Enter your choice
```

||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

```
*********************
*                   *
*   F.E.M. Task  1  *
*                   *
*********************

 -1 - Upper level menu                              (enter -1 or CR)
  1 - Numerical parameters                          (enter  1)
  2 - Create a sub-task                             (enter  2)
  3 - Redefine global parameters of a sub-task      (enter  3)
  4 - Assign the pressure                           (enter  4)
  # - Assign the stream function
  6 - Mesh-mesh interpolation                       (enter  6)
  # - Define species
  # - Define reactions
  9 - 3D Rotation                                   (enter  9)
 10 - Local shear-rate                              (enter 10)
 11 - Inelastic stress tensor                       (enter 11)
 12 - Mixing efficiency                             (enter 12)

Enter your choice

1
```

```
                              ****************************
                              *                          *
                              *   Numerical parameters   *
                              *                          *
                              ****************************

          - No previous solution
          - Maximum number of iterations                   =      50
          - Convergence test                               =   1.0000000E-08
          - Divergence test                                =   1.0000000E+04
          - Coupled iterations for moving bound.
          - Surface kinematic condition

      -1 - Upper level menu                                 (enter -1 or CR)
       1 - Start with an old result file                    (enter  1)
       2 - Modify the max number of iterations              (enter  2)
       3 - Modify the convergence test                      (enter  3)
       4 - Modify the divergence test                       (enter  4)
       5 - Decoupled iterations for moving bound.           (enter  5)
       # - Modify the max number of 'fixed' iterations
       # - Modify the convergence test ('fixed' iterations)
       8 - Line kinematic condition                         (enter  8)

 Enter your choice


                              **************************
                              *                        *
                              *   Assign the pressure  *
                              *                        *
                              **************************

            The calculation of the pressure field associated
           with the following velocity field requires a point at
           which the value of the pressure is imposed.

            1 : Field of sub-task 3D Rotation

           -1 - Upper level menu                  (enter -1 or CR)
            1 - Pressure condition for field  1  (enter  1)

 Enter your choice

1


                              *************************
                              *                       *
                              *   Pressure condition  *
                              *                       *
                              *************************

  The pressure field is currently imposed at the node
 closest to coordinates :

    X = 0.0000000E+00   Y = 0.0000000E+00   Z = 0.0000000E+00

 Do you agree with this ?
 Enter y(es) or n(o)   (CR=yes)

 Current value of pressure condition is  1.0000000E+05
 Enter its new value  (CR=no modification)
```

```
                    ******************************
                    *                            *
                    *   Mesh-mesh interpolation  *
                    *                            *
                    ******************************

          Mesh-mesh interpolations interpolate all potential
          velocity, pressure, temperature, and stress fields
          from a previous result to the current task.

          Such an interpolation has not yet been defined.

              -1 - Accept current setup  (enter -1 or CR)
               1 - Create interpolations (enter  1)
               # - Modify file names

 Enter your choice


           ************************************************
           *                                              *
           *   Redefine global parameters of a sub-task   *
           *                                              *
           ************************************************

                          Sub-task : 3D Rotation

        -1 - Upper level menu                          (enter -1 or CR)
         1 - Delete the current sub-task               (enter  1)
         2 - Modify the title of the current sub-task  (enter  2)
         3 - Modify the type of the current sub-task   (enter  3)

 Enter your choice
3

           ************************************************
           *                                              *
           *   Redefine global parameters of a sub-task   *
           *                                              *
           ************************************************


 > 1 - Generalized Newtonian isothermal flow problem         (enter  1 or
CR)
   2 - Generalized Newtonian non-isothermal flow problem     (enter  2)
   3 - Heat conduction problem                               (enter  3)
   4 - Differential viscoelastic isothermal flow problem     (enter  4)
   5 - Differential viscoelastic non-isothermal flow problem (enter  5)
   # - Postprocessor
   7 - Integral viscoelastic isothermal flow problem         (enter  7)
   8 - Integral viscoelastic non-isothermal flow problem     (enter  8)
   9 - Darcy isothermal flow problem                         (enter  9)
  10 - Darcy non-isothermal flow problem                     (enter 10)
  11 - Slightly compressible flow problem                    (enter 11)
   # - Mass transfer problem
  13 - Potential problem                                     (enter 13)
   # - Film model : Gen. Newtonian isothermal
   # - Film model : Gen. Newtonian non-isothermal
   # - Film model : Viscoelastic isothermal
   # - Thickness for film
   # - Transport of species
   # - Closure

 Enter your choice
```

```
                    ******************
                    *                *
                    *   3D Rotation  *
                    *                *
                    ******************


          -1 - Upper level menu           (enter -1 or CR)
           1 - Domain of the sub-task     (enter  1)
           2 - Material data              (enter  2)
           3 - Flow boundary conditions   (enter  3)
           # - Global remeshing
           # - Rigid translation
           6 - Interpolation              (enter  6)
           # - Bubbling

 Enter your choice

1
              ******************************
              *                            *
              *   Domain of the sub-task   *
              *                            *
              ******************************

        The current sub-task is defined on : whole mesh

      -2 - Make the current domain empty (enter -2)
      -1 - Upper level menu              (enter -1 or CR)
       # - Extension to the whole mesh
       1 - Removal of subdomain  1       (enter  1)

 Enter your choice


                   ********************
                   *                  *
                   *   Material data  *
                   *                  *
                   ********************


     -1 - Upper level menu                        (enter -1 or CR)
      1 - Shear-rate dependence of viscosity      (enter  1)
      # - Temperature dependence of viscosity
      # - Differential viscoelastic models
      # - Integral Viscoelastic models
      5 - Density                                 (enter  5)
      6 - Inertia terms                           (enter  6)
      # - Coefficient of thermal expansion
      # - Thermal conductivity
      # - Heat capacity per unit mass
      # - Viscous heating
     11 - Gravity                                 (enter 11)
      # - Average temperature
      # - Heat source per unit volume

 Enter your choice

1
```

```
*******************************************
*                                         *
*   Shear-rate dependence of viscosity    *
*                                         *
*******************************************


 -1 - Upper level menu      (enter -1 or CR)
  1 - Constant viscosity    (enter  1)
  2 - Bird-Carreau law      (enter  2)
> 3 - Power law             (enter  3)
  4 - Bingham law           (enter  4)
  5 - Herschel-Bulkley law  (enter  5)
  6 - Cross law             (enter  6)

Enter your choice

                    *****************
                    *               *
                    *   Power law   *
                    *               *
                    *****************

                    f(g) = fac * g**(expo-1)

        fac        =  4.4000000E+03     expo        =  5.0000000E-01

         -1 - Upper level menu      (enter -1 or CR)
          1 - Modification of fac   (enter  1)
          2 - Modification of expo  (enter  2)

Enter your choice


                    ***************
                    *             *
                    *   Density   *
                    *             *
                    ***************


                density     =  8.0000000E+02

         -1 - Upper level menu         (enter -1 or CR)
          1 - Modification of density  (enter  1)

Enter your choice

                    *********************
                    *                   *
                    *   Inertia terms   *
                    *                   *
                    *********************

Inertia will be neglected in the momentum equations

Do you agree with this ?
Enter y(es) or n(o)  (CR=yes)
```

```
***************
*             *
*   Gravity   *
*             *
***************


gx          =  0.0000000E+00       gy          = -9.8100000E+00
gz          =  0.0000000E+00

            -1 - Upper level menu   (enter -1 or CR)
             1 - Modification of gx (enter  1)
             2 - Modification of gy (enter  2)
             3 - Modification of gz (enter  3)

 Enter your choice

||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

                *******************************
                *                             *
                *   Flow boundary conditions  *
                *                             *
                *******************************


      -1 - Upper level menu                       (enter -1 or CR)
       # - Normal flow rate imposed
       1 - Inflow along boundary  1               (enter  1)
       2 - vx,vy,vz imposed along boundary  2     (enter  2)
       3 - vx,vy,vz imposed along boundary  3     (enter  3)
       4 - vn & vs imposed along boundary  4      (enter  4)
       5 - Outflow along boundary  5              (enter  5)

 Select the boundary condition you want to modify
1

          ************************************************
          *                                              *
          *   Flow boundary condition along boundary  1  *
          *                                              *
          ************************************************

               Current choice : Inflow
                                No force postprocessor

 -2 - Enable force postprocessor                                     (enter -2)
 -1 - Upper level menu                                               (enter -1 or
CR)
  # - Interface
  1 - Normal and tangential velocities imposed  (vn & vs)            (enter  1)
  2 - Normal and tangential forces imposed  (fn & fs)                (enter  2)
  3 - Normal velocity and tangential force imposed  (vn & fs)        (enter  3)
  4 - Normal force and tangential velocity imposed  (fn & vs)        (enter  4)
  5 - Slip conditions                                                (enter  5)
  6 - Plane of symmetry  ( fs=0 & vn=0 )                             (enter  6)
> 7 - Inflow                                                         (enter  7)
  8 - Outflow                                                        (enter  8)
  9 - Free surface                                                   (enter  9)
 10 - Global force imposed                                           (enter 10)
 11 - Cartesian velocities imposed  (vx,vy,vz)                       (enter 11)

 Enter your choice

7
```

```
                    ******************************
                    *                            *
                    *  Inflow along boundary  1  *
                    *                            *
                    ******************************

 Current value of the volumetric flow rate is  5.2000000E-07
 Enter its new value  (CR=no modification)


          ************************************************
          *                                              *
          *   Flow boundary condition along boundary  2  *
          *                                              *
          ************************************************

               Current choice : vx,vy,vz imposed
                                No force postprocessor

 -2 - Enable force postprocessor                                       (enter -2)
 -1 - Upper level menu                                                 (enter -1 or
CR)
  # - Interface
  1 - Normal and tangential velocities imposed  (vn & vs)              (enter  1)
  2 - Normal and tangential forces imposed  (fn & fs)                  (enter  2)
  3 - Normal velocity and tangential force imposed  (vn & fs)          (enter  3)
  4 - Normal force and tangential velocity imposed  (fn & vs)          (enter  4)
  5 - Slip conditions                                                  (enter  5)
  6 - Plane of symmetry  ( fs=0 & vn=0 )                               (enter  6)
  7 - Inflow                                                           (enter  7)
  8 - Outflow                                                          (enter  8)
  9 - Free surface                                                     (enter  9)
 10 - Global force imposed                                             (enter 10)
>11 - Cartesian velocities imposed  (vx,vy,vz)                         (enter 11)

 Enter your choice
11


             ****************************************
             *                                      *
             *   vx,vy,vz imposed along boundary  2 *
             *                                      *
             ****************************************

     The cartesian velocities are expressed as the
     combination of a rotation and of a translation.

   - Coordinates of the 1st point of the rotation axis
      x1 =-1.7505000E-02  y1 = 0.0000000E+00  z1 = 0.0000000E+00
   - Coordinates of the 2nd point of the rotation axis
      x2 =-1.7505000E-02  y2 = 0.0000000E+00  z2 =-1.0000000E-02
   - Angular velocity = -6.2831850E+00
   - Components of the translation velocity
      tx = 0.0000000E+00  ty = 0.0000000E+00  tz = 0.0000000E+00

    -1 - Upper level menu                          (enter -1 or CR)
     1 - Modification of 1st point of the axis     (enter  1)
     2 - Modification of 2nd point of the axis     (enter  2)
     3 - Modification of angular velocity          (enter  3)
     4 - Modification of translation velocity      (enter  4)

 Enter your choice
```

```
                    *******************************************
                    *                                         *
                    *   vx,vy,vz imposed along boundary  3    *
                    *                                         *
                    *******************************************

             The cartesian velocities are expressed as the
             combination of a rotation and of a translation.

           - Coordinates of the 1st point of the rotation axis
              x1 = 1.7505000E-02  y1 = 0.0000000E+00  z1 = 0.0000000E+00
           - Coordinates of the 2nd point of the rotation axis
              x2 = 1.7505000E-02  y2 = 0.0000000E+00  z2 =-1.0000000E-02
           - Angular velocity = -6.2831850E+00
           - Components of the translation velocity
              tx = 0.0000000E+00  ty = 0.0000000E+00  tz = 0.0000000E+00

            -1 - Upper level menu                      (enter -1 or CR)
             1 - Modification of 1st point of the axis (enter  1)
             2 - Modification of 2nd point of the axis (enter  2)
             3 - Modification of angular velocity      (enter  3)
             4 - Modification of translation velocity  (enter  4)

 Enter your choice


                 ***********************************************
                 *                                             *
                 *   Flow boundary condition along boundary  4 *
                 *                                             *
                 ***********************************************

                      Current choice : vn & vs imposed
                                       No force postprocessor

  -2 - Enable force postprocessor                                  (enter -2)
  -1 - Upper level menu                                            (enter -1 or
CR)
   # - Interface
 > 1 - Normal and tangential velocities imposed  (vn & vs)         (enter  1)
   2 - Normal and tangential forces imposed  (fn & fs)             (enter  2)
   3 - Normal velocity and tangential force imposed  (vn & fs)     (enter  3)
   4 - Normal force and tangential velocity imposed  (fn & vs)     (enter  4)
   5 - Slip conditions                                             (enter  5)
   6 - Plane of symmetry  ( fs=0 & vn=0 )                          (enter  6)
   7 - Inflow                                                      (enter  7)
   8 - Outflow                                                     (enter  8)
   9 - Free surface                                                (enter  9)
  10 - Global force imposed                                        (enter 10)
  11 - Cartesian velocities imposed  (vx,vy,vz)                    (enter 11)

 Enter your choice
1

                    ****************************************
                    *                                      *
                    *   vn & vs imposed along boundary  4  *
                    *                                      *
                    ****************************************

                      -   vn  : constant =  0.0000000E+00

               -1 - Upper level menu                  (enter -1 or CR)
                1 - Constant                          (enter  1)
                2 - Linear function of coordinates    (enter  2)

 Enter your choice
```

```
                    *****************************************
                    *                                       *
                    *   vn & vs imposed along boundary  4   *
                    *                                       *
                    *****************************************

                       -    vs   : constant =  0.0000000E+00

               -1 - Upper level menu                  (enter -1 or CR)
                # - Constant
                # - Linear function of coordinates

 Enter your choice


                 *************************************************
                 *                                               *
                 *   Flow boundary condition along boundary  5   *
                 *                                               *
                 *************************************************

                     Current choice : Outflow
                                      No force postprocessor

 -2 - Enable force postprocessor                                  (enter -2)
 -1 - Upper level menu                                            (enter -1 or
CR)
  # - Interface
  1 - Normal and tangential velocities imposed  (vn & vs)         (enter  1)
  2 - Normal and tangential forces imposed  (fn & fs)             (enter  2)
  3 - Normal velocity and tangential force imposed  (vn & fs)     (enter  3)
  4 - Normal force and tangential velocity imposed  (fn & vs)     (enter  4)
  5 - Slip conditions                                             (enter  5)
  6 - Plane of symmetry  ( fs=0 & vn=0 )                          (enter  6)
  7 - Inflow                                                      (enter  7)
> 8 - Outflow                                                     (enter  8)
  9 - Free surface                                                (enter  9)
 10 - Global force imposed                                        (enter 10)
 11 - Cartesian velocities imposed  (vx,vy,vz)                    (enter 11)

 Enter your choice
8


                         *********************************
                         *                               *
                         *   Outflow along boundary  5   *
                         *                               *
                         *********************************

 Zero normal derivative on velocity imposed

  Do you agree with this ?
 Enter y(es) or n(o)  (CR=yes)
```

||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

```
                    *********************
                    *                   *
                    *   Interpolation   *
                    *                   *
                    *********************

          Current setup : Linear coordinates
                          Quadratic velocities, linear pressure
                          Picard iterations on viscosity(g)
                          No upwinding in momentum equations

   -1 - Upper level menu                                        (enter -1 or
CR)
    1 - Quadratic coordinates                                   (enter  1)
    # - Quadratic element for stresses
    # - 4x4 SU element for stresses
    # - 4x4 SUPG element for stresses
    # - EVSS for stresses
    # - EVSS SU for stresses
    # - EVSS SUPG for stresses
    8 - Quadratic velocities, linear pressure                   (enter  8)
    9 - Mini-element for velocities, constant pressure          (enter  9)
   10 - Linear velocities, constant pressure                    (enter 10)
   11 - Quadratic velocities, linear discontinuous pressure     (enter 11)
   12 - Newton iterations on viscosity(g)                       (enter 12)
    # - Linear    element for temperature
    # - Quadratic element for temperature
    # - 2x2       element for temperature
    # - 4x4       element for temperature
    # - Upwinding in momentum equations
    # - Sub-interpolation

 Enter your choice
```

||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||

```
                    ************************
                    *                      *
                    *   Local shear-rate   *
                    *                      *
                    ************************

          -1 - Upper level menu                  (enter -1)
           1 - Local shear-rate                  (enter  1 or CR)
           2 - Viscosity                         (enter  2)
           3 - Rate of deformation tensor        (enter  3)
           4 - Inelastic stress tensor           (enter  4)
           5 - Viscous heating                   (enter  5)
           # - Total extra-stress tensor
           7 - Residence time                    (enter  7)
           # - Tracking of material points
           9 - Tracking of a material property   (enter  9)
          10 - Forces on slices                  (enter 10)

Enter your choice

The calculation will be done on S1.

Hit CR to continue
```

```
********************************
*                              *
*   Inelastic stress tensor    *
*                              *
********************************
```

```
-1 - Upper level menu                    (enter -1)
 1 - Local shear-rate                    (enter  1)
 2 - Viscosity                           (enter  2)
 3 - Rate of deformation tensor          (enter  3)
 4 - Inelastic stress tensor             (enter  4 or CR)
 5 - Viscous heating                     (enter  5)
 # - Total extra-stress tensor
 7 - Residence time                      (enter  7)
 # - Tracking of material points
 9 - Tracking of a material property     (enter  9)
10 - Forces on slices                    (enter 10)

Enter your choice

The calculation will be done on S1.

Hit CR to continue
```

```
*************************
*                       *
*   Mixing efficiency   *
*                       *
*************************
```

```
-1 - Upper level menu                    (enter -1)
 1 - Local shear-rate                    (enter  1 or CR)
 2 - Viscosity                           (enter  2)
 3 - Rate of deformation tensor          (enter  3)
 4 - Inelastic stress tensor             (enter  4)
 5 - Viscous heating                     (enter  5)
 # - Total extra-stress tensor
 7 - Residence time                      (enter  7)
 # - Tracking of material points
 9 - Tracking of a material property     (enter  9)
10 - Forces on slices                    (enter 10)

Enter your choice

The calculation will be done on S1.

Hit CR to continue
```

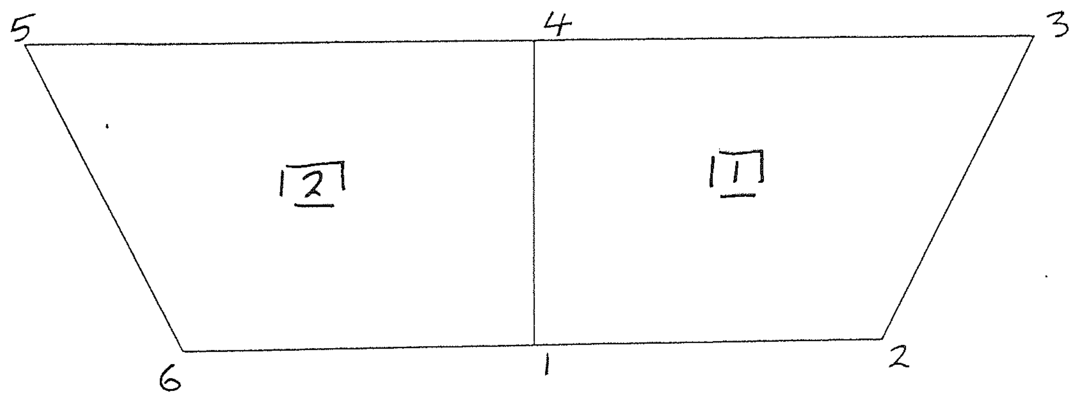
APPENDIX N

Screw Channel: Y-Z Cross Section

Vertex No.	Angle (degree)	Hypoth (m)	X value (m)	Y value (m)
1	-	-	0.0000000	0.0000000
2	-	-	0.0057362	0.0000000
3	27.6666667	0.0048900	0.0082350	0.0048900
4	-	0.0048900	0.0000000	0.0048900
5	27.6666667	0.0048900	-0.0082350	0.0048900
6	-	-	-0.0057362	0.0000000

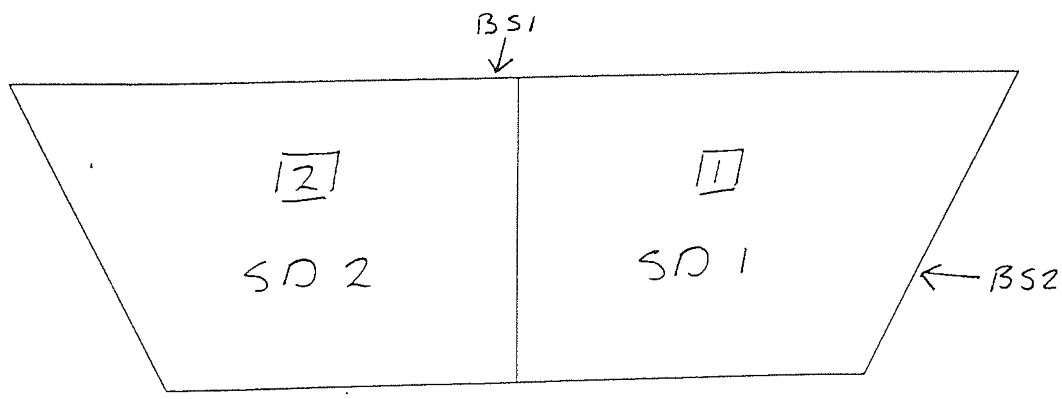
Appendix O:

Macro-Vertex and -Element Numbering Schemes Assigned to the 2D Mesh Representing the Y-Z Cross Section Through the Screw Channel



Appendix P:

Sub-Domain Numbering Scheme Assigned for the Time-Dependent Flow Problem



Screw Channel: Y-Z Cross Section APPENDIX Q

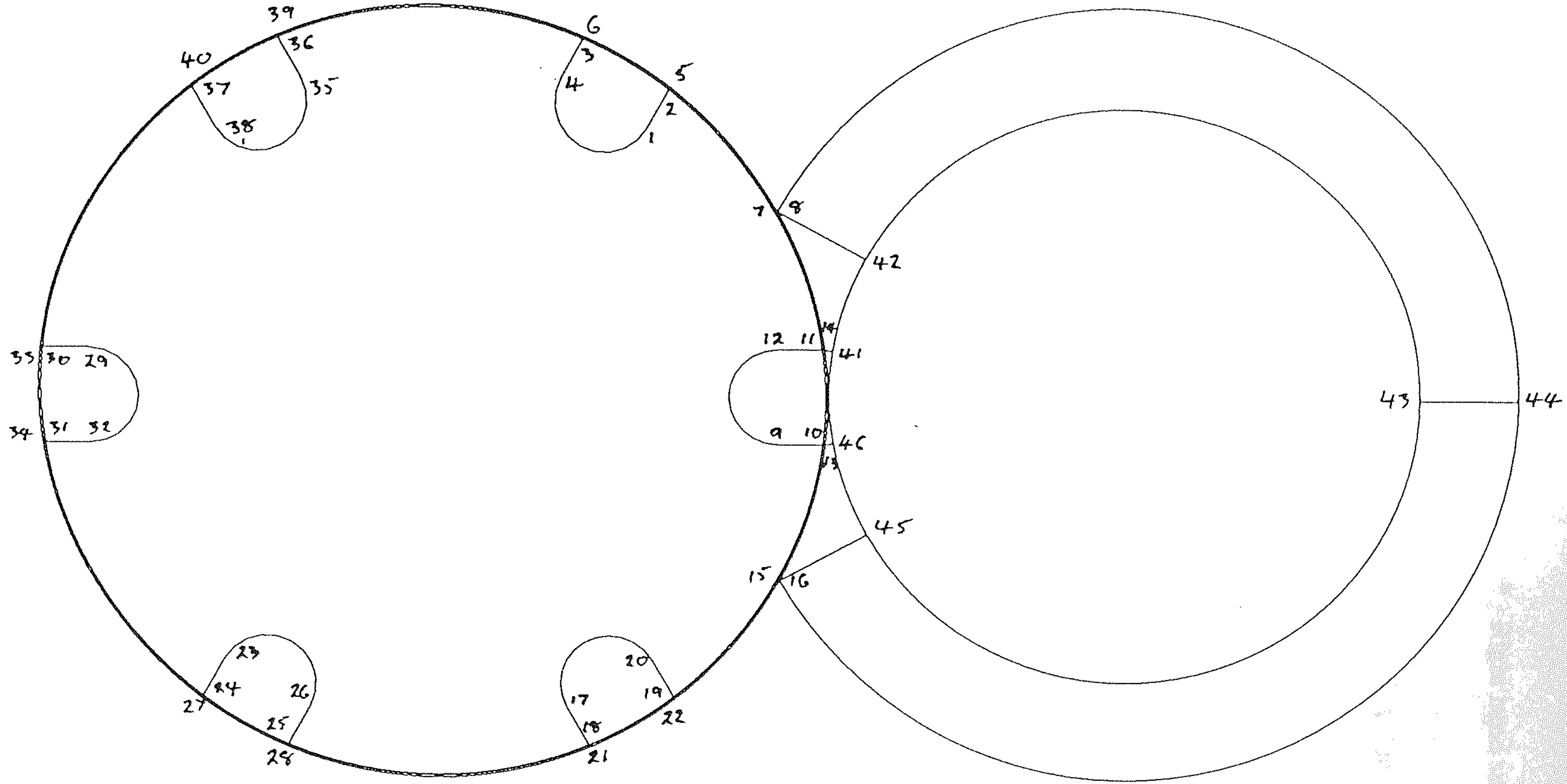
Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
1	1 = 2	Straight	#	#	#	***20***	***Cheb***	***Twrds Macr Vert 2***	Gen. Chk. B.	400
	2 = 3	Straight	#	#	#	***20***	***Cheb***	***Twrds Both Extrms***		
	3 = 4	Straight	#	#	#	20	Cheb	Twrds Macr Vert 3		
	4 = 1	Straight	#	#	#	20	Cheb	Twrds Both Extrms		
2	4 = 5	Straight	#	#	#	***20***	***Cheb***	***Twrds Macr Vert 5***	Gen. Chk. B.	400
	5 = 6	Straight	#	#	#	20	Cheb	Twrds Both Extrms		
	6 = 1	Straight	#	#	#	20	Cheb	Twrds Macr Vert 6		
	1 = 4	#	#	#	#	20	Cheb	Twrds Both Extrms		
									Total =	800

Appendix R: Boundary Numbering Scheme for the 2D Y-Z Screw Channel Mesh.

	Outer Barrel Wall			Screw Flight		
Bound No.	1 Start	(Direction)	1 End	2 Start	(Direction)	2 End
	3	(=> 4)	5	5	(=> 6)	3

Appendix S:

Macro-Vertex Numbering Scheme Assigned to Meshes Pertaining to Set 1 Representations of the 2D Mixing Discs.



APPENDIX T1

Mixing Disc - $\alpha = 0°$

* - Right hand screw

Vertex No.	Angle (degree)	Hypoth (m)	X value (m)	Y value (m)	Value Change?	To Change
1	38.1450264	0.0176455	-0.0066062	0.0138773	Yes	1 x 0° Angle
2	37.2307299	0.0198625	-0.0054877	0.0158146	Yes	1 x 0° Angle
3	22.7692701	0.0198625	-0.0098178	0.0183146	Yes	1 x 0° Angle
4	21.8549736	0.0176455	-0.0109363	0.0163773	Yes	1 x 0° Angle
5	37.1780498	0.0200075	-0.0054146	0.0159412	Yes	1 x 0° Angle
6	22.8219502	0.0200075	-0.0097447	0.0184412	Yes	1 x 0° Angle
7	61.0357344	0.0198625	-0.0001269	0.0096187	No	#
8	61.0357344	0.0200075	0.0000000	0.0096889	No	#
9	98.1450264	0.0176455	-0.0000375	-0.0025000	Yes	1 x 0° Angle
10	97.2307299	0.0198625	0.0021995	-0.0025000	Yes	1 x 0° Angle
11	82.7692701	0.0198625	0.0021995	0.0025000	Yes	1 x 0° Angle
12	81.8549736	0.0176455	-0.0000375	0.0025000	Yes	1 x 0° Angle
13	97.1780498	0.0200075	0.0023457	-0.0025000	Yes	1 x 0° Angle
14	82.8219502	0.0200075	0.0023457	0.0025000	Yes	1 x 0° Angle
15	118.9642656	0.0198625	-0.0001269	-0.0096187	No	#
16	118.9642656	0.0200075	0.0000000	-0.0096889	No	#
17	158.1450264	0.0176455	-0.0109363	-0.0163773	Yes	1 x 0° Angle
18	157.2307299	0.0198625	-0.0098178	-0.0183146	Yes	1 x 0° Angle
19	142.7692701	0.0198625	-0.0054877	-0.0158146	Yes	1 x 0° Angle
20	141.8549736	0.0176455	-0.0066062	-0.0138773	Yes	1 x 0° Angle
21	157.1780498	0.0200075	-0.0097447	-0.0184412	Yes	1 x 0° Angle
22	142.8219502	0.0200075	-0.0054146	-0.0159412	Yes	1 x 0° Angle
23	218.1450264	0.0176455	-0.0284038	-0.0138773	Yes	1 x 0° Angle
24	217.2307299	0.0198625	-0.0295223	-0.0158146	Yes	1 x 0° Angle
25	202.7692701	0.0198625	-0.0251922	-0.0183146	Yes	1 x 0° Angle
26	201.8549736	0.0176455	-0.0240737	-0.0163773	Yes	1 x 0° Angle
27	217.1780498	0.0200075	-0.0295954	-0.0159412	Yes	1 x 0° Angle
28	202.8219502	0.0200075	-0.0252653	-0.0184412	Yes	1 x 0° Angle
29	278.1450264	0.0176455	-0.0349725	0.0025000	Yes	1 x 0° Angle

Vertex No.	Angle (degree)	Hypoth (m)		X value (m)	Y value (m)	Value Change?	To Change
30	277.2307299	0.0198625		-0.0372095	0.0025000	Yes	1 x 0° Angle
31	262.7692701	0.0198625		-0.0372095	-0.0025000	Yes	1 x 0° Angle
32	261.8549736	0.0176455		-0.0349725	-0.0025000	Yes	1 x 0° Angle
33	277.1780498	0.0200075		-0.0373557	0.0025000	Yes	1 x 0° Angle
34	262.8219502	0.0200075		-0.0373557	-0.0025000	Yes	1 x 0° Angle
35	338.1450264	0.0176455		-0.0240737	0.0163773	Yes	1 x 0° Angle
36	337.2307299	0.0198625		-0.0251922	0.0183146	Yes	1 x 0° Angle
37	322.7692701	0.0198625		-0.0295223	0.0158146	Yes	1 x 0° Angle
38	321.8549736	0.0176455		-0.0284038	0.0138773	Yes	1 x 0° Angle
39	337.1780498	0.0200075		-0.0252653	0.0184412	Yes	1 x 0° Angle
40	322.8219502	0.0200075		-0.0295954	0.0159412	Yes	1 x 0° Angle
41	9.3646553	0.0149675	*	0.0027370	0.0024355	Yes	Care! 1 x Angle
42	28.9642656	0.0149675	*	0.0044096	0.0072482	No	#
43	90.0000000	0.0149675	*	0.0324725	0.0000000	No	#
44	90.0000000	0.0200075	*	0.0375125	0.0000000	No	#
45	-28.9642656	0.0149675	*	0.0044096	-0.0072482	No	#
46	-9.3646553	0.0149675	*	0.0027370	-0.0024355	Yes	Care! 1 x Angle

APPENDIX T2

Mixing Disc - $\alpha = 5°$

* - Right hand screw

Vertex No.	Angle (degree)	Hypoth (m)	X value (m)	Y value (m)	Value Change?	To Change
1	33.1450264	0.0176455	-0.0078571	0.0147744	Yes	1 x 5° Angle
2	32.2307299	0.0198625	-0.0069117	0.0168018	Yes	1 x 5° Angle
3	17.7692701	0.0198625	-0.0114433	0.0189149	Yes	1 x 5° Angle
4	16.8549736	0.0176455	-0.0123887	0.0168875	Yes	1 x 5° Angle
5	32.1780498	0.0200075	-0.0068500	0.0169343	Yes	1 x 5° Angle
6	17.8219502	0.0200075	-0.0113815	0.0190474	Yes	1 x 5° Angle
7	61.0357344	0.0198625	-0.0001269	0.0096187	No	#
8	61.0357344	0.0200075	0.0000000	0.0096889	No	#
9	93.1450264	0.0176455	0.0001139	-0.0009681	Yes	1 x 5° Angle
10	92.2307299	0.0198625	0.0023424	-0.0007731	Yes	1 x 5° Angle
11	77.7692701	0.0198625	0.0019067	0.0042079	Yes	1 x 5° Angle
12	76.8549736	0.0176455	-0.0003219	0.0040129	Yes	1 x 5° Angle
13	92.1780498	0.0200075	0.0024880	-0.0007604	Yes	1 x 5° Angle
14	77.8219502	0.0200075	0.0020523	0.0042206	Yes	1 x 5° Angle
15	118.9642656	0.0198625	-0.0001269	-0.0096187	No	#
16	118.9642656	0.0200075	0.0000000	-0.0096889	No	#
17	153.1450264	0.0176455	-0.0095339	-0.0157425	Yes	1 x 5° Angle
18	152.2307299	0.0198625	-0.0082508	-0.0175750	Yes	1 x 5° Angle
19	137.7692701	0.0198625	-0.0041551	-0.0147071	Yes	1 x 5° Angle
20	136.8549736	0.0176455	-0.0054382	-0.0128746	Yes	1 x 5° Angle
21	152.1780498	0.0200075	-0.0081670	-0.0176947	Yes	1 x 5° Angle
22	137.8219502	0.0200075	-0.0040712	-0.0148268	Yes	1 x 5° Angle
23	213.1450264	0.0176455	-0.0271529	-0.0147744	Yes	1 x 5° Angle
24	212.2307299	0.0198625	-0.0280983	-0.0168018	Yes	1 x 5° Angle
25	197.7692701	0.0198625	-0.0235667	-0.0189149	Yes	1 x 5° Angle
26	196.8549736	0.0176455	-0.0226213	-0.0168875	Yes	1 x 5° Angle
27	212.1780498	0.0200075	-0.0281600	-0.0169343	Yes	1 x 5° Angle
28	197.8219502	0.0200075	-0.0236285	-0.0190474	Yes	1 x 5° Angle
29	273.1450264	0.0176455	-0.0351239	0.0009681	Yes	1 x 5° Angle

Vertex No.	Angle (degree)	Hypoth (m)		X value (m)	Y value (m)	Value Change?	To Change
30	272.2307299	0.0198625		-0.0373524	0.0007731	Yes	1 x 5° Angle
31	257.7692701	0.0198625		-0.0369167	-0.0042079	Yes	1 x 5° Angle
32	256.8549736	0.0176455		-0.0346881	-0.0040129	Yes	1 x 5° Angle
33	272.1780498	0.0200075		-0.0374980	0.0007604	Yes	1 x 5° Angle
34	257.8219502	0.0200075		-0.0370623	-0.0042206	Yes	1 x 5° Angle
35	333.1450264	0.0176455		-0.0254761	0.0157425	Yes	1 x 5° Angle
36	332.2307299	0.0198625		-0.0267592	0.0175750	Yes	1 x 5° Angle
37	317.7692701	0.0198625		-0.0308549	0.0147071	Yes	1 x 5° Angle
38	316.8549736	0.0176455		-0.0295718	0.0128746	Yes	1 x 5° Angle
39	332.1780498	0.0200075		-0.0268430	0.0176947	Yes	1 x 5° Angle
40	317.8219502	0.0200075		-0.0309388	0.0148268	Yes	1 x 5° Angle
41	15.2765375	0.0149675	*	0.0030664	0.0039436	Yes	Care! 1 x Angle
42	28.9642656	0.0149675	*	0.0044096	0.0072482	No	#
43	90.0000000	0.0149675	*	0.0324725	0.0000000	No	#
44	90.0000000	0.0200075	*	0.0375125	0.0000000	No	#
45	-28.9642656	0.0149675	*	0.0044096	-0.0072482	No	#
46	-2.8987010	0.0149675	*	0.0025567	-0.0007569	Yes	Care! 1 x Angle

APPENDIX T3

Mixing Disc - $\alpha = 10°$

* - Right hand screw

Vertex No.	Angle (degree)	Hypoth (m)	X value (m)	Y value (m)	Value Change?	To Change
1	28.1450264	0.0176455	-0.0091815	0.0155590	Yes	1 x 10° Angle
2	27.2307299	0.0198625	-0.0084164	0.0176612	Yes	1 x 10° Angle
3	12.7692701	0.0198625	-0.0131149	0.0193713	Yes	1 x 10° Angle
4	11.8549736	0.0176455	-0.0138800	0.0172691	Yes	1 x 10° Angle
5	27.1780498	0.0200075	-0.0083664	0.0177985	Yes	1 x 10° Angle
6	12.8219502	0.0200075	-0.0130649	0.0195086	Yes	1 x 10° Angle
7	61.0357344	0.0198625	-0.0001269	0.0096187	No	#
8	61.0357344	0.0200075	0.0000000	0.0096889	No	#
9	88.1450264	0.0176455	0.0001312	0.0005712	Yes	1 x 10° Angle
10	87.2307299	0.0198625	0.0023343	0.0009596	Yes	1 x 10° Angle
11	72.7692701	0.0198625	0.0014661	0.0058837	Yes	1 x 10° Angle
12	71.8549736	0.0176455	-0.0007370	0.0054952	Yes	1 x 10° Angle
13	87.1780498	0.0200075	0.0024782	0.0009850	Yes	1 x 10° Angle
14	72.8219502	0.0200075	0.0016100	0.0059091	Yes	1 x 10° Angle
15	118.9642656	0.0198625	-0.0001269	-0.0096187	No	#
16	118.9642656	0.0200075	0.0000000	-0.0096889	No	#
17	148.1450264	0.0176455	-0.0081922	-0.0149879	Yes	1 x 10° Angle
18	147.2307299	0.0198625	-0.0067543	-0.0167015	Yes	1 x 10° Angle
19	132.7692701	0.0198625	-0.0029241	-0.0134876	Yes	1 x 10° Angle
20	131.8549736	0.0176455	-0.0043620	-0.0117739	Yes	1 x 10° Angle
21	147.1780498	0.0200075	-0.0066603	-0.0168135	Yes	1 x 10° Angle
22	132.8219502	0.0200075	-0.0028301	-0.0135995	Yes	1 x 10° Angle
23	208.1450264	0.0176455	-0.0258285	-0.0155590	Yes	1 x 10° Angle
24	207.2307299	0.0198625	-0.0265936	-0.0176612	Yes	1 x 10° Angle
25	192.7692701	0.0198625	-0.0218951	-0.0193713	Yes	1 x 10° Angle
26	191.8549736	0.0176455	-0.0211300	-0.0172691	Yes	1 x 10° Angle
27	207.1780498	0.0200075	-0.0266436	-0.0177985	Yes	1 x 10° Angle
28	192.8219502	0.0200075	-0.0219451	-0.0195086	Yes	1 x 10° Angle
29	268.1450264	0.0176455	-0.0351412	-0.0005712	Yes	1 x 10° Angle

Vertex No.	Angle (degree)	Hypoth (m)		X value (m)	Y value (m)	Value Change?	To Change
30	267.2307299	0.0198625		-0.0373443	-0.0009596	Yes	1 x 10° Angle
31	252.7692701	0.0198625		-0.0364761	-0.0058837	Yes	1 x 10° Angle
32	251.8549736	0.0176455		-0.0342730	-0.0054952	Yes	1 x 10° Angle
33	267.1780498	0.0200075		-0.0374882	-0.0009850	Yes	1 x 10° Angle
34	252.8219502	0.0200075		-0.0366200	-0.0059091	Yes	1 x 10° Angle
35	328.1450264	0.0176455		-0.0268178	0.0149879	Yes	1 x 10° Angle
36	327.2307299	0.0198625		-0.0282557	0.0167015	Yes	1 x 10° Angle
37	312.7692701	0.0198625		-0.0320859	0.0134876	Yes	1 x 10° Angle
38	311.8549736	0.0176455		-0.0306480	0.0117739	Yes	1 x 10° Angle
39	327.1780498	0.0200075		-0.0283497	0.0168135	Yes	1 x 10° Angle
40	312.8219502	0.0200075		-0.0321799	0.0135995	Yes	1 x 10° Angle
41	20.3928988	0.0149675	*	0.0034756	0.0052155	Yes	Care! 1 x Angle
42	28.9642656	0.0149675	*	0.0044096	0.0072482	No	#
43	90.0000000	0.0149675	*	0.0324725	0.0000000	No	#
44	90.0000000	0.0200075	*	0.0375125	0.0000000	No	#
45	-28.9642656	0.0149675	*	0.0044096	-0.0072482	No	#
46	-3.7504231	0.0149675	*	0.0025696	0.0009790	Yes	Care! 1 x Angle

APPENDIX T4

Mixing Disc - $\alpha = 15°$

* - Right hand screw

Vertex No.	Angle (degree)	Hypoth (m)	X value (m)	Y value (m)	Value Change?	To Change
1	23.1450264	0.0176455	-0.0105693	0.0162253	Yes	1 x 15° Angle
2	22.2307299	0.0198625	-0.0099903	0.0183861	Yes	1 x 15° Angle
3	7.7692701	0.0198625	-0.0148199	0.0196802	Yes	1 x 15° Angle
4	6.8549736	0.0176455	-0.0153989	0.0175194	Yes	1 x 15° Angle
5	22.1780498	0.0200075	-0.0099524	0.0185273	Yes	1 x 15° Angle
6	7.8219502	0.0200075	-0.0147821	0.0198213	Yes	1 x 15° Angle
7	61.0357344	0.0198625	-0.0001269	0.0096187	No	#
8	61.0357344	0.0200075	0.0000000	0.0096889	No	#
9	83.1450264	0.0176455	0.0000144	0.0021061	Yes	1 x 15° Angle
10	82.2307299	0.0198625	0.0021752	0.0026851	Yes	1 x 15° Angle
11	67.7692701	0.0198625	0.0008811	0.0075147	Yes	1 x 15° Angle
12	66.8549736	0.0176455	-0.0012797	0.0069357	Yes	1 x 15° Angle
13	82.1780498	0.0200075	0.0023163	0.0027229	Yes	1 x 15° Angle
14	67.8219502	0.0200075	0.0010223	0.0075526	Yes	1 x 15° Angle
15	118.9642656	0.0198625	-0.0001269	-0.0096187	No	#
16	118.9642656	0.0200075	0.0000000	-0.0096889	No	#
17	143.1450264	0.0176455	-0.0069214	-0.0141192	Yes	1 x 15° Angle
18	142.2307299	0.0198625	-0.0053396	-0.0157010	Yes	1 x 15° Angle
19	127.7692701	0.0198625	-0.0018040	-0.0121654	Yes	1 x 15° Angle
20	126.8549736	0.0176455	-0.0033858	-0.0105836	Yes	1 x 15° Angle
21	142.1780498	0.0200075	-0.0052362	-0.0158043	Yes	1 x 15° Angle
22	127.8219502	0.0200075	-0.0017007	-0.0122688	Yes	1 x 15° Angle
23	203.1450264	0.0176455	-0.0244407	-0.0162253	Yes	1 x 15° Angle
24	202.2307299	0.0198625	-0.0250197	-0.0183861	Yes	1 x 15° Angle
25	187.7692701	0.0198625	-0.0201901	-0.0196802	Yes	1 x 15° Angle
26	186.8549736	0.0176455	-0.0196111	-0.0175194	Yes	1 x 15° Angle
27	202.1780498	0.0200075	-0.0250576	-0.0185273	Yes	1 x 15° Angle
28	187.8219502	0.0200075	-0.0202279	-0.0198213	Yes	1 x 15° Angle
29	263.1450264	0.0176455	-0.0350244	-0.0021061	Yes	1 x 15° Angle

Vertex No.	Angle (degree)	Hypoth (m)		X value (m)	Y value (m)	Value Change?	To Change
30	262.2307299	0.0198625		-0.0371852	-0.0026851	Yes	1 x 15° Angle
31	247.7692701	0.0198625		-0.0358911	-0.0075147	Yes	1 x 15° Angle
32	246.8549736	0.0176455		-0.0337303	-0.0069357	Yes	1 x 15° Angle
33	262.1780498	0.0200075		-0.0373263	-0.0027229	Yes	1 x 15° Angle
34	247.8219502	0.0200075		-0.0360323	-0.0075526	Yes	1 x 15° Angle
35	323.1450264	0.0176455		-0.0280886	0.0141192	Yes	1 x 15° Angle
36	322.2307299	0.0198625		-0.0296704	0.0157010	Yes	1 x 15° Angle
37	307.7692701	0.0198625		-0.0332060	0.0121654	Yes	1 x 15° Angle
38	306.8549736	0.0176455		-0.0316242	0.0105836	Yes	1 x 15° Angle
39	322.1780498	0.0200075		-0.0297738	0.0158043	Yes	1 x 15° Angle
40	307.8219502	0.0200075		-0.0333093	0.0122688	Yes	1 x 15° Angle
41	24.6177007	0.0149675	*	0.0038979	0.0062349	Yes	Care! 1 x Angle
42	28.9642656	0.0149675	*	0.0044096	0.0072482	No	#
43	90.0000000	0.0149675	*	0.0324725	0.0000000	No	#
44	90.0000000	0.0200075	*	0.0375125	0.0000000	No	#
45	-28.9642656	0.0149675	*	0.0044096	-0.0072482	No	#
46	-10.1636493	0.0149675	*	0.0027724	0.0026412	Yes	Care! 1 x Angle

APPENDIX T5

Mixing Disc - $\alpha = 20°$

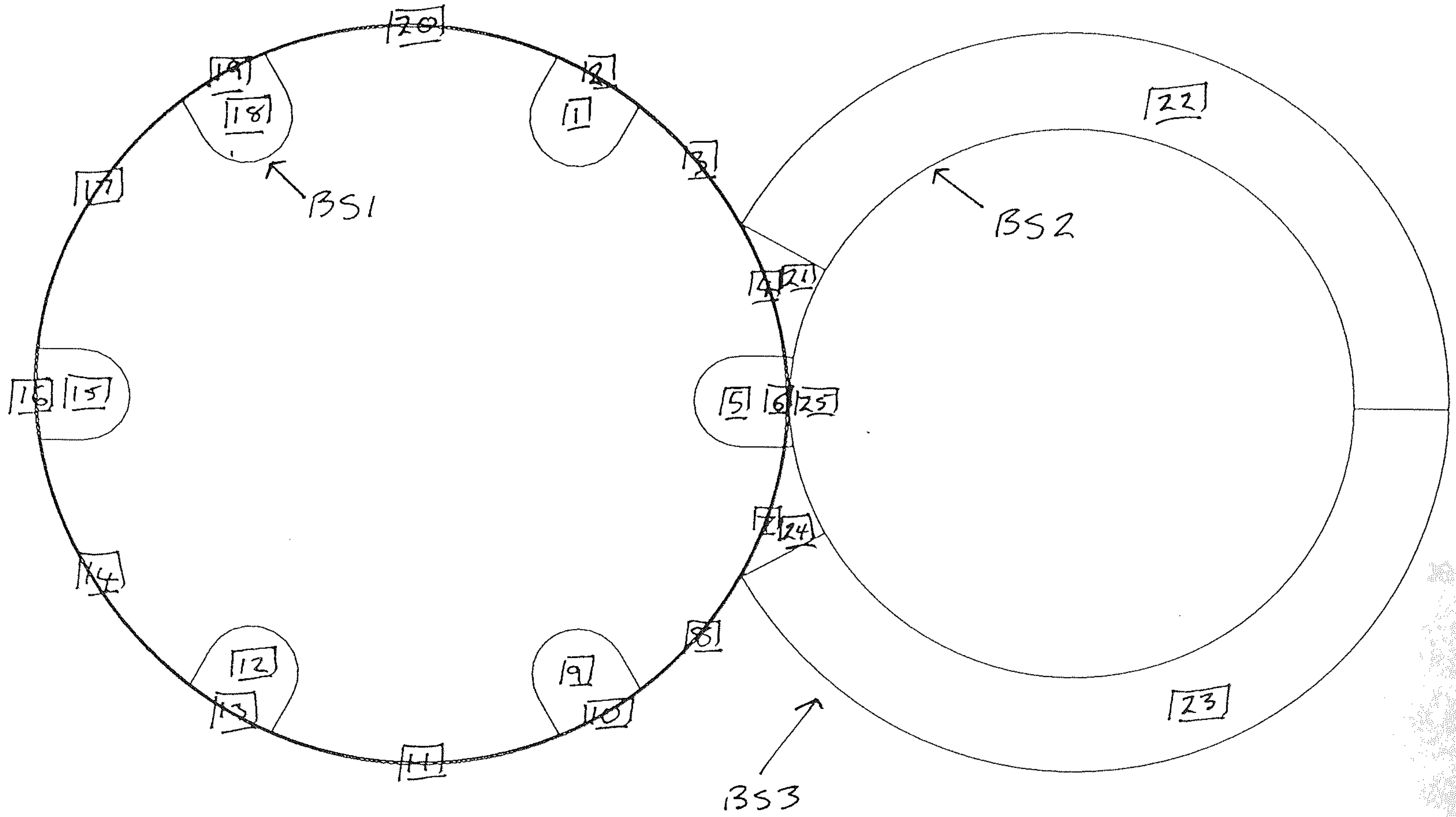
* - Right hand screw

Vertex No.	Angle (degree)	Hypoth (m)	X value (m)	Y value (m)	Value Change?	To Change
1	18.1450264	0.0176455	-0.0120098	0.0167680	Yes	1 x 20° Angle
2	17.2307299	0.0198625	-0.0116213	0.0189711	Yes	1 x 20° Angle
3	2.7692701	0.0198625	-0.0165454	0.0198393	Yes	1 x 20° Angle
4	1.8549736	0.0176455	-0.0169338	0.0176362	Yes	1 x 20° Angle
5	17.1780498	0.0200075	-0.0115959	0.0191150	Yes	1 x 20° Angle
6	2.8219502	0.0200075	-0.0165200	0.0199832	Yes	1 x 20° Angle
7	61.0357344	0.0198625	-0.0001269	0.0096187	No	#
8	61.0357344	0.0200075	0.0000000	0.0096889	No	#
9	78.1450264	0.0176455	-0.0002359	0.0036250	Yes	1 x 20° Angle
10	77.2307299	0.0198625	0.0018663	0.0043901	Yes	1 x 20° Angle
11	62.7692701	0.0198625	0.0001562	0.0090886	Yes	1 x 20° Angle
12	61.8549736	0.0176455	-0.0019460	0.0083235	Yes	1 x 20° Angle
13	77.1780498	0.0200075	0.0020036	0.0044401	Yes	1 x 20° Angle
14	62.8219502	0.0200075	0.0002935	0.0091386	Yes	1 x 20° Angle
15	118.9642656	0.0198625	-0.0001269	-0.0096187	No	#
16	118.9642656	0.0200075	0.0000000	-0.0096889	No	#
17	138.1450264	0.0176455	-0.0057311	-0.0131430	Yes	1 x 20° Angle
18	137.2307299	0.0198625	-0.0040174	-0.0145809	Yes	1 x 20° Angle
19	122.7692701	0.0198625	-0.0008035	-0.0107507	Yes	1 x 20° Angle
20	121.8549736	0.0176455	-0.0025171	-0.0093128	Yes	1 x 20° Angle
21	137.1780498	0.0200075	-0.0039055	-0.0146749	Yes	1 x 20° Angle
22	122.8219502	0.0200075	-0.0006915	-0.0108447	Yes	1 x 20° Angle
23	198.1450264	0.0176455	-0.0230002	-0.0167680	Yes	1 x 20° Angle
24	197.2307299	0.0198625	-0.0233887	-0.0189711	Yes	1 x 20° Angle
25	182.7692701	0.0198625	-0.0184646	-0.0198393	Yes	1 x 20° Angle
26	181.8549736	0.0176455	-0.0180762	-0.0176362	Yes	1 x 20° Angle
27	197.1780498	0.0200075	-0.0234141	-0.0191150	Yes	1 x 20° Angle
28	182.8219502	0.0200075	-0.0184900	-0.0199832	Yes	1 x 20° Angle
29	258.1450264	0.0176455	-0.0347741	-0.0036250	Yes	1 x 20° Angle

Vertex No.	Angle (degree)	Hypoth (m)		X value (m)	Y value (m)	Value Change?	To Change
30	257.2307299	0.0198625		-0.0368763	-0.0043901	Yes	1 x 20° Angle
31	242.7692701	0.0198625		-0.0351662	-0.0090886	Yes	1 x 20° Angle
32	241.8549736	0.0176455		-0.0330640	-0.0083235	Yes	1 x 20° Angle
33	257.1780498	0.0200075		-0.0370136	-0.0044401	Yes	1 x 20° Angle
34	242.8219502	0.0200075		-0.0353035	-0.0091386	Yes	1 x 20° Angle
35	318.1450264	0.0176455		-0.0292789	0.0131430	Yes	1 x 20° Angle
36	317.2307299	0.0198625		-0.0309926	0.0145809	Yes	1 x 20° Angle
37	302.7692701	0.0198625		-0.0342065	0.0107507	Yes	1 x 20° Angle
38	301.8549736	0.0176455		-0.0324929	0.0093128	Yes	1 x 20° Angle
39	317.1780498	0.0200075		-0.0311045	0.0146749	Yes	1 x 20° Angle
40	302.8219502	0.0200075		-0.0343185	0.0108447	Yes	1 x 20° Angle
41	27.9663870	0.0149675	*	0.0042854	0.0070191	Yes	Care! 1 x Angle
42	28.9642656	0.0149675	*	0.0044096	0.0072482	No	#
43	90.0000000	0.0149675	*	0.0324725	0.0000000	No	#
44	90.0000000	0.0200075	*	0.0375125	0.0000000	No	#
45	-28.9642656	0.0149675	*	0.0044096	-0.0072482	No	#
46	-15.9834379	0.0149675	*	0.0031161	0.0041214	Yes	Care! 1 x Angle

Appendix U:

Macro-Element Numbering Schemes Assigned to Each of the Set 1, 2D Mixing Disc Meshes.



Mixing discs - $\alpha = 0° - 20°$ APPENDIX V

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
1	1 = 2	Straight	#	#	#	*	*12*	Cheb	Twrds Both Extrms	Prop. Ch. B.	120
	2 = 3	Circular	0.0198625	Left	Right	*	*10*	Cheb	Twrds Both Extrms	Towards	
	3 = 4	Straight	#	#	#		12	Cheb	Twrds Both Extrms	4 = 1	
	4 = 1	Circular	0.0025001	Right	Left		10	Uniform	#		
2	2 = 5	Straight	#	#	#	*	*2*	Uniform	#	Prop. Ch. B.	20
	5 = 6	Circular	0.0200075	Left	Right		10	Cheb	Twrds Both Extrms	Towards	
	6 = 3	Straight	#	#	#		2	Uniform	#	5 = 6	
	3 = 2	#	#	#	#		10	Cheb	Twrds Both Extrms		
3	2 = 7	Circular	0.0198625	Right	Left	****	*8,12*	Cheb	Twrds Both Extrms	Prop. Ch. B.	16
	7 = 8	Straight	#	#	#		2	Uniform	#	Towards	24
	8 = 5	Circular	0.0200075	Right	Left		8,12	Cheb	Twrds Both Extrms	2 = 7	
	5 = 2	#	#	#	#		2	Uniform	#		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
4	7 = 11	Circular	0.0198625	Right	Left	****	*15,3*	Cheb	Twrds Both Extrms	Prop. Ch. B.	30
	11 = 14	Straight	#	#	#		2	Uniform	#	Towards	6
	14 = 8	Circular	0.0200075	Right	Left		15,3	Cheb	Twrds Both Extrms	7 = 11	
	8 = 7	#	#	#	#		2	Uniform	#		
5	9 = 10	Straight	#	#	#	*	*12*	Cheb	Twrds Both Extrms	Prop. Ch. B.	144
	10 = 11	Circular	0.0198625	Left	Right	*	*12*	Cheb	Twrds Both Extrms	Towards	
	11 = 12	Straight	#	#	#		12	Cheb	Twrds Both Extrms	12 = 9	
	12 = 9	Circular	0.0025001	Right	Left		12	Uniform	#		
6	10 = 13	Straight	#	#	#		2	Uniform	#	Prop. Ch. B.	24
	13 = 14	Circular	0.0200075	Left	Right		12	Cheb	Twrds Both Extrms	Towards	
	14 = 11	#	#	#	#		2	Uniform	#	13 = 14	
	11 = 10	#	#	#	#		12	Cheb	Twrds Both Extrms		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
7	10 = 15	Circular	0.0198625	Right	Left	****	*15,27*	Cheb	Twrds Both Extrms	Prop. Ch. B.	30
	15 = 16	Straight	#	#	#		2	Uniform	#	Towards	54
	16 = 13	Circular	0.0200075	Right	Left		15,27	Cheb	Twrds Both Extrms	10 = 15	
	13 = 10	#	#	#	#		2	Uniform	#		
8	15 = 19	Circular	0.0198625	Right	Left	****	*8,4*	Cheb	Twrds Both Extrms	Prop. Ch. B.	16
	19 = 22	Straight	#	#	#		2	Uniform	#	Towards	8
	22 = 16	Circular	0.0200075	Right	Left		8,4	Cheb	Twrds Both Extrms	15 = 19	
	16 = 15	#	#	#	#		2	Uniform	#		
9	17 = 18	Straight	#	#	#	*	*12*	Cheb	Twrds Both Extrms	Prop. Ch. B.	144
	18 = 19	Circular	0.0198625	Left	Right	*	*12*	Cheb	Twrds Both Extrms	Towards	
	19 = 20	Straight	#	#	#		12	Cheb	Twrds Both Extrms	20 = 17	
	20 = 17	Circular	0.0025001	Right	Left		12	Uniform	#		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
10	18 = 21	Straight	#	#	#		2	Uniform	#	Prop. Ch. B.	24
	21 = 22	Circular	0.0200075	Left	Right		12	Cheb	Twrds Both Extrms	Towards	
	22 = 19	#	#	#	#		2	Uniform	#	21 = 22	
	19 = 18	#	#	#	#		12	Cheb	Twrds Both Extrms		
11	18 = 25	Circular	0.0198625	Right	Left	*	*16*	Cheb	Twrds Both Extrms	Prop. Ch. B.	32
	25 = 28	Straight	#	#	#		2	Uniform	#	Towards	
	28 = 21	Circular	0.0200075	Right	Left		16	Cheb	Twrds Both Extrms	18 = 25	
	21 = 18	#	#	#	#		2	Uniform	#		
12	23 = 24	Straight	#	#	#	*	*12*	Cheb	Twrds Both Extrms	Prop. Ch. B.	120
	24 = 25	Circular	0.0198625	Left	Right	*	*10*	Cheb	Twrds Both Extrms	Towards	
	25 = 26	Straight	#	#	#		12	Cheb	Twrds Both Extrms	26 = 23	
	26 = 23	Circular	0.0025001	Right	Left		10	Uniform	#		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
13	24 = 27	Straight	#	#	#		2	Uniform	#	Prop. Ch. B.	20
	27 = 28	Circular	0.0200075	Left	Right		10	Cheb	Twrds Both Extrms	Towards	
	28 = 25	#	#	#	#		2	Uniform	#	27 = 28	
	25 = 24	#	#	#	#		10	Cheb	Twrds Both Extrms		
14	24 = 31	Circular	0.0198625	Right	Left	*	*16*	Cheb	Twrds Both Extrms	Prop. Ch. B.	32
	31 = 34	Straight	#	#	#		2	Uniform	#	Towards	
	34 = 27	Circular	0.0200075	Right	Left		16	Cheb	Twrds Both Extrms	24 = 31	
	27 = 24	#	#	#	#		2	Uniform	#		
15	29 = 30	Straight	#	#	#	*	*12*	Cheb	Twrds Both Extrms	Prop. Ch. B.	120
	30 = 31	Circular	0.0198625	Left	Right	*	*10*	Cheb	Twrds Both Extrms	Towards	
	31 = 32	Straight	#	#	#		12	Cheb	Twrds Both Extrms	32 = 29	
	32 = 29	Circular	0.0025001	Right	Left		10	Uniform	#		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
16	30 = 33	Straight	#	#	#		2	Uniform	#	Prop. Ch. B.	20
	33 = 34	Circular	0.0200075	Left	Right		10	Cheb	Twrds Both Extrms	Towards	
	34 = 31	#	#	#	#		2	Uniform	#	33 = 34	
	31 = 30	#	#	#	#		10	Cheb	Twrds Both Extrms		
17	30 = 37	Circular	0.0198625	Right	Left	*	*16*	Cheb	Twrds Both Extrms	Prop. Ch. B.	32
	37 = 40	Straight	#	#	#		2	Uniform	#	Towards	
	40 = 33	Circular	0.0200075	Right	Left		16	Cheb	Twrds Both Extrms	30 = 37	
	33 = 30	#	#	#	#		2	Uniform	#		
18	35 = 36	Straight	#	#	#	*	*12*	Cheb	Twrds Both Extrms	Prop. Ch. B.	120
	36 = 37	Circular	0.0198625	Left	Right	*	*10*	Cheb	Twrds Both Extrms	Towards	
	37 = 38	Straight	#	#	#		12	Cheb	Twrds Both Extrms	38 = 35	
	38 = 35	Circular	0.0025001	Right	Left		10	Uniform	#		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
19	36 = 39	Straight	#	#	#		2	Uniform	#	Prop. Ch. B.	20
	39 = 40	Circular	0.0200075	Left	Right		10	Cheb	Twrds Both Extrms	Towards	
	40 = 37	#	#	#	#		2	Uniform	#	39 = 40	
	37 = 36	#	#	#	#		10	Cheb	Twrds Both Extrms		
20	36 = 3	Circular	0.0198625	Left	Right	*	*16*	Cheb	Twrds Both Extrms	Prop. Ch. B.	32
	3 = 6	#	#	#	#		2	Uniform	#	Towards	
	6 = 39	Circular	0.0200075	Left	Right		16	Cheb	Twrds Both Extrms	36 = 3	
	39 = 36	#	#	#	#		2	Uniform	#		
21	41 = 42	Circular	0.0149675	Right	Left		15,3	Cheb	Twrds Both Extrms	Prop. Ch. B.	180
	42 = 8	Straight	#	#	#	*	*12*	Cheb	Twrds Both Extrms	Towards	36
	8 = 14	#	#	#	#		15,3	Cheb	Twrds Both Extrms	41 = 42	
	14 = 41	Straight	#	#	#		12	Cheb	Twrds Both Extrms		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
22	42 = 43	Circular	0.0149675	Right	Left	*	*40*	Cheb	Twrds Macr Vert 42	Prop. Ch. B.	480
	43 = 44	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	
	44 = 8	Circular	0.0200075	Right	Left		40	Cheb	Twrds Macr Vert 8	42 = 43	
	8 = 42	#	#	#	#		12	Cheb	Twrds Both Extrms		
23	43 = 45	Circular	0.0149675	Right	Left	*	*40*	Cheb	Twrds Macr Vert 45	Prop. Ch. B.	480
	45 = 16	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	
	16 = 44	Circular	0.0200075	Right	Left		40	Cheb	Twrds Macr Vert 16	43 = 45	
	44 = 43	#	#	#	#		12	Cheb	Twrds Both Extrms		
24	45 = 46	Circular	0.0149675	Right	Left		15,27	Cheb	Twrds Both Extrms	Prop. Ch. B.	180
	46 = 13	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	324
	13 = 16	#	#	#	#		15,27	Cheb	Twrds Both Extrms	45 = 46	
	16 = 45	#	#	#	#		12	Cheb	Twrds Both Extrms		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
25	46 = 41	Circular	0.0149675	Right	Left		12	Cheb	Twrds Both Extrms	Prop. Ch. B.	144
	41 = 14	#	#	#	#		12	Cheb	Twrds Both Extrms	Towards	
	14 = 13	#	#	#	#		12	Cheb	Twrds Both Extrms	46 = 41	
	13 = 46	#	#	#	#		12	Cheb	Twrds Both Extrms		
										Total =	2580
											2580

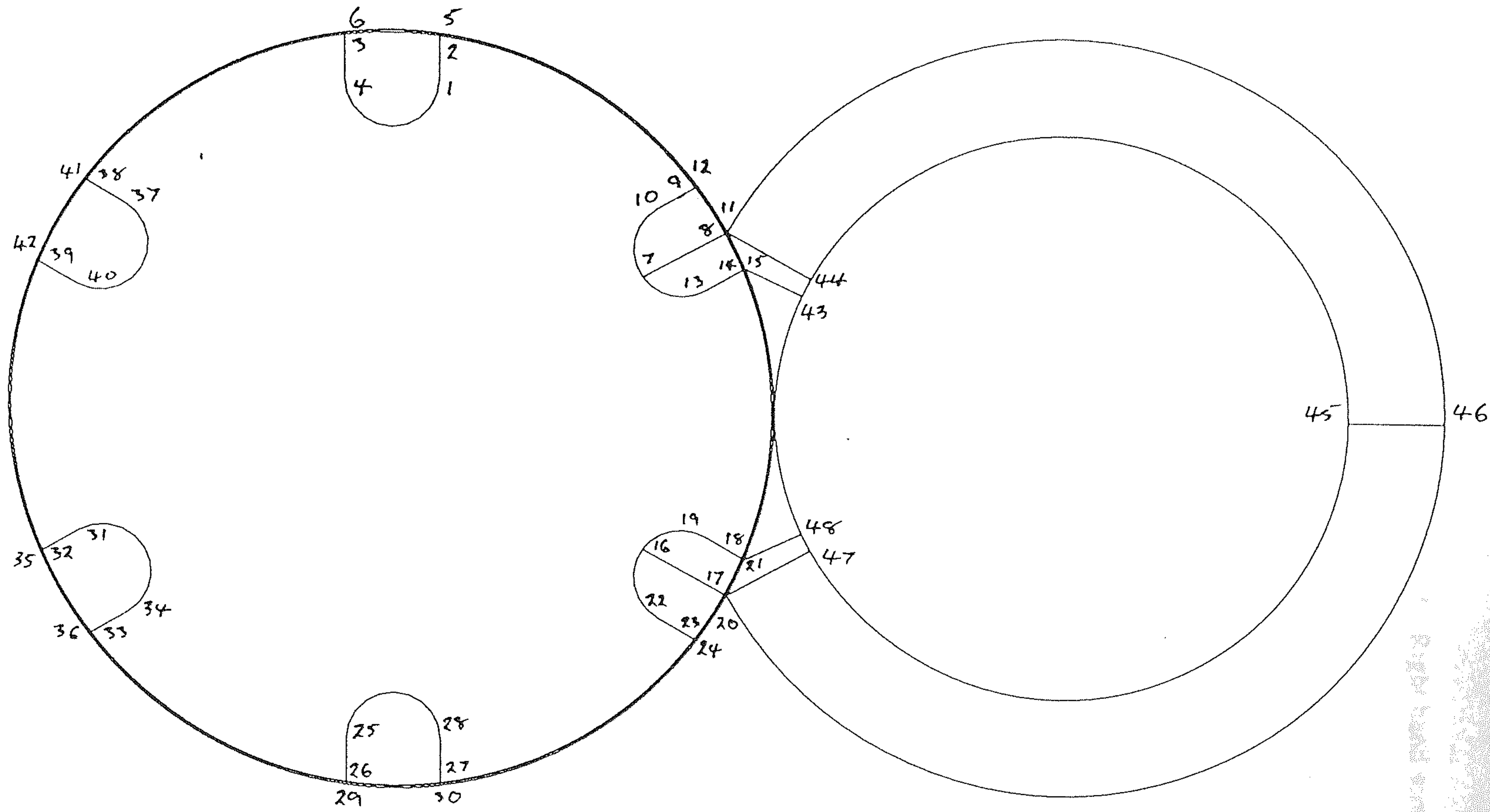
**** - Represents
Progress Between Values
Shown For Each 5° Rotation

Appendix W: Boundary Numbering Scheme Used for Each of the Set 1, 2D Mixing Disc Meshes.

	Left CICo-TSE Element			Right CICo-TSE Element			Outer Barrel Wall		
Bound No.	1 Start	(Direction)	1 End	2 Start	(Direction)	2 End	3 Start	(Direction)	3 End
	1	(=> 2)	1	41	(=> 42)	41	8	(=> 5)	8

546

Appendix X:
Macro-Vertex Numbering
Scheme Assigned to Meshes
Pertaining to Set 2
Representations of the 2D
Mixing Discs.



APPENDIX YI

Mixing Disc - $\alpha = 25°$

* - Right hand screw

Vertex No.	Angle (degree)	Hypoth (m)	X value (m)	Y value (m)	Value Change?	To Change
1	13.1450264	0.0176455	-0.0134921	0.0171831	Yes	1 x 25° Angle
2	12.2307299	0.0198625	-0.0132971	0.0194117	Yes	1 x 25° Angle
3	-2.2307299	0.0198625	-0.0182781	0.0198474	Yes	1 x 25° Angle
4	-3.1450264	0.0176455	-0.0184731	0.0176189	Yes	1 x 25° Angle
5	12.1780498	0.0200075	-0.0132844	0.0195573	Yes	1 x 25° Angle
6	-2.1780498	0.0200075	-0.0182654	0.0199930	Yes	1 x 25° Angle
7	61.0357344	0.0156746	-0.0037909	0.0075907	Yes	Hypoth
8	61.0357344	0.0198625	-0.0001269	0.0096187	No	#
9	57.7692701	0.0198625	-0.0007032	0.0105933	Yes	1 x 25° Angle
10	56.8549736	0.0176455	-0.0027306	0.0096479	Yes	1 x 25° Angle
11	61.0357344	0.0200075	0.0000000	0.0096889	No	#
12	57.8219502	0.0200075	-0.0005707	0.0106550	Yes	1 x 25° Angle
13	73.1450264	0.0176455	-0.0006175	0.0051163	Yes	1 x 25° Angle
14	72.2307299	0.0198625	0.0014099	0.0060617	Yes	1 x 25° Angle
15	72.1780498	0.0200075	0.0015424	0.0061235	Yes	1 x 25° Angle
16	118.9642656	0.0156746	-0.0037909	-0.0075907	Yes	Hypoth
17	118.9642656	0.0198625	-0.0001269	-0.0096187	No	#
18	117.7692701	0.0198625	0.0000700	-0.0092542	Yes	1 x 25° Angle
19	116.8549736	0.0176455	-0.0017625	-0.0079711	Yes	1 x 25° Angle
20	118.9642656	0.0200075	0.0000000	-0.0096889	No	#
21	117.8219502	0.0200075	0.0001897	-0.0093380	Yes	1 x 25° Angle
22	133.1450264	0.0176455	-0.0046304	-0.0120668	Yes	1 x 25° Angle
23	132.2307299	0.0198625	-0.0027979	-0.0133499	Yes	1 x 25° Angle
24	132.1780498	0.0200075	-0.0026782	-0.0134338	Yes	1 x 25° Angle
25	193.1450264	0.0176455	-0.0215179	-0.0171831	Yes	1 x 25° Angle
26	192.2307299	0.0198625	-0.0217129	-0.0194117	Yes	1 x 25° Angle
27	177.7692701	0.0198625	-0.0167319	-0.0198474	Yes	1 x 25° Angle
28	176.8549736	0.0176455	-0.0165369	-0.0176189	Yes	1 x 25° Angle
29	192.1780498	0.0200075	-0.0217256	-0.0195573	Yes	1 x 25° Angle

Vertex No.	Angle (degree)	Hypoth (m)		X value (m)	Y value (m)	Value Change?	To Change
30	177.8219502	0.0200075		-0.0167446	-0.0199930	Yes	1 x 25° Angle
31	253.1450264	0.0176455		-0.0343925	-0.0051163	Yes	1 x 25° Angle
32	252.2307299	0.0198625		-0.0364199	-0.0060617	Yes	1 x 25° Angle
33	237.7692701	0.0198625		-0.0343068	-0.0105933	Yes	1 x 25° Angle
34	236.8549736	0.0176455		-0.0322794	-0.0096479	Yes	1 x 25° Angle
35	252.1780498	0.0200075		-0.0365524	-0.0061235	Yes	1 x 25° Angle
36	237.8219502	0.0200075		-0.0344393	-0.0106550	Yes	1 x 25° Angle
37	313.1450264	0.0176455		-0.0303796	0.0120668	Yes	1 x 25° Angle
38	312.2307299	0.0198625		-0.0322121	0.0133499	Yes	1 x 25° Angle
39	297.7692701	0.0198625		-0.0350800	0.0092542	Yes	1 x 25° Angle
40	296.8549736	0.0176455		-0.0332475	0.0079711	Yes	1 x 25° Angle
41	312.1780498	0.0200075		-0.0323318	0.0134338	Yes	1 x 25° Angle
42	297.8219502	0.0200075		-0.0351997	0.0093380	Yes	1 x 25° Angle
43	20.9875551	0.0149675	*	0.0035305	0.0053608	Yes	Care! 1 x Angle
44	28.9642656	0.0149675	*	0.0044096	0.0072482	No	#
45	90.0000000	0.0149675	*	0.0324725	0.0000000	No	#
46	90.0000000	0.0200075	*	0.0375125	0.0000000	No	#
47	-28.9642656	0.0149675	*	0.0044096	-0.0072482	No	#
48	-28.3376184	0.0149675	*	0.0043311	-0.0071046	Yes	Care! 1 x Angle

APPENDIX Y2

Mixing Disc - $\alpha = 30°$

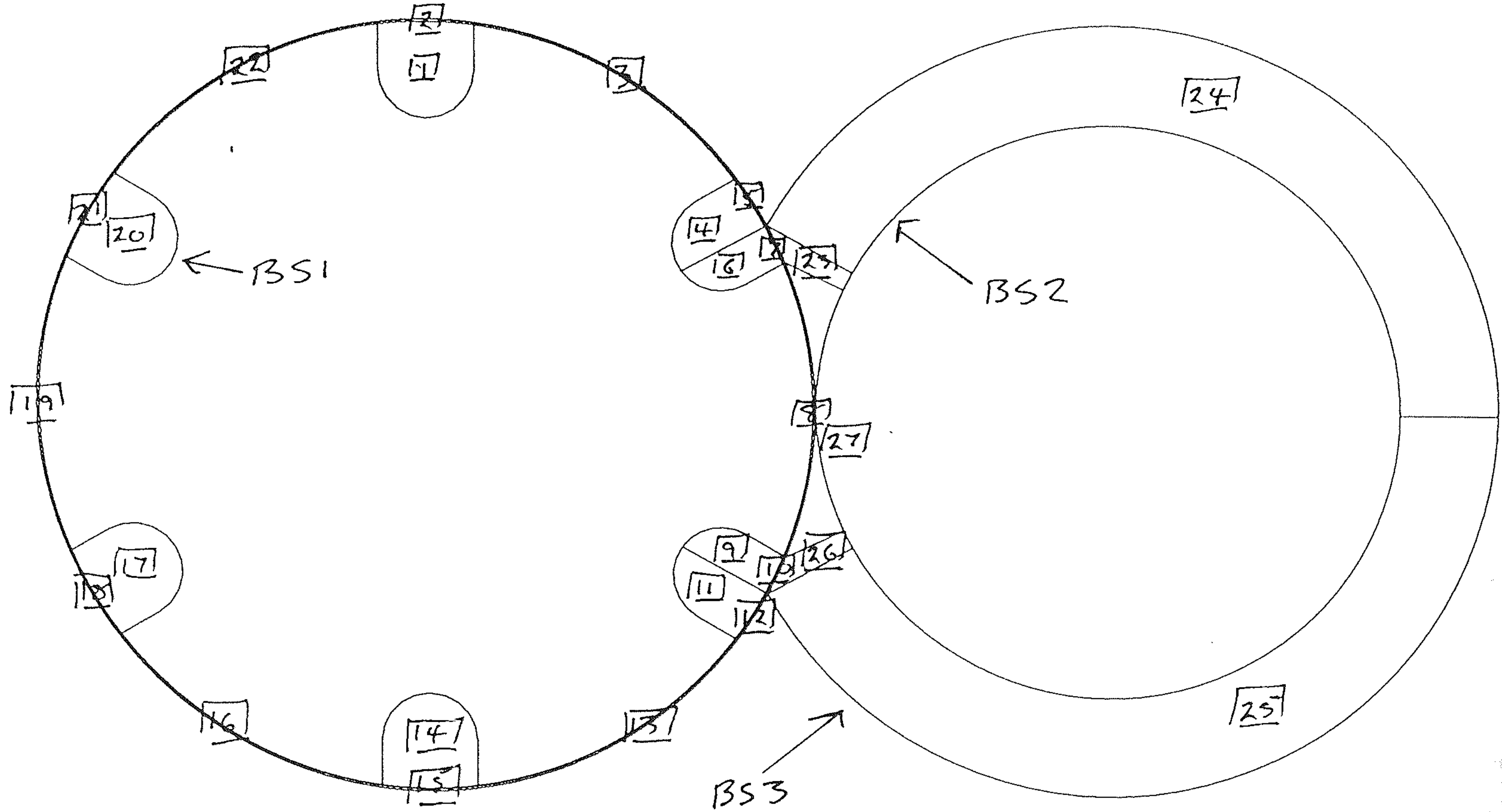
* - Right hand screw

Vertex No.	Angle (degree)	Hypoth (m)	X value (m)	Y value (m)	Value Change?	To Change
1	8.1450264	0.0176455	-0.0150050	0.0174675	Yes	1 x 30° Angle
2	7.2307299	0.0198625	-0.0150050	0.0197045	Yes	1 x 30° Angle
3	-7.2307299	0.0198625	-0.0200050	0.0197045	Yes	1 x 30° Angle
4	-8.1450264	0.0176455	-0.0200050	0.0174675	Yes	1 x 30° Angle
5	7.1780498	0.0200075	-0.0150050	0.0198507	Yes	1 x 30° Angle
6	-7.1780498	0.0200075	-0.0200050	0.0198507	Yes	1 x 30° Angle
7	61.0357344	0.0149847	-0.0043946	0.0072565	Yes	Hypoth
8	61.0357344	0.0198625	-0.0001269	0.0096187	No	#
9	52.7692701	0.0198625	-0.0016904	0.0120173	Yes	1 x 30° Angle
10	51.8549736	0.0176455	-0.0036277	0.0108988	Yes	1 x 30° Angle
11	61.0357344	0.0200075	0.0000000	0.0096889	No	#
12	52.8219502	0.0200075	-0.0015638	0.0120904	Yes	1 x 30° Angle
13	68.1450264	0.0176455	-0.0011277	0.0065687	Yes	1 x 30° Angle
14	67.2307299	0.0198625	0.0008096	0.0076872	Yes	1 x 30° Angle
15	67.1780498	0.0200075	0.0009362	0.0077603	Yes	1 x 30° Angle
16	118.9642656	0.0149847	-0.0043946	-0.0072565	Yes	Hypoth
17	118.9642656	0.0198625	-0.0001269	-0.0096187	No	#
18	112.7692701	0.0198625	0.0008096	-0.0076872	Yes	1 x 30° Angle
19	111.8549736	0.0176455	-0.0011277	-0.0065687	Yes	1 x 30° Angle
20	118.9642656	0.0200075	0.0000000	-0.0096889	No	#
21	112.8219502	0.0200075	0.0009362	-0.0077603	Yes	1 x 30° Angle
22	128.1450264	0.0176455	-0.0036277	-0.0108988	Yes	1 x 30° Angle
23	127.2307299	0.0198625	-0.0016904	-0.0120173	Yes	1 x 30° Angle
24	127.1780498	0.0200075	-0.0015638	-0.0120904	Yes	1 x 30° Angle
25	188.1450264	0.0176455	-0.0200050	-0.0174675	Yes	1 x 30° Angle
26	187.2307299	0.0198625	-0.0200050	-0.0197045	Yes	1 x 30° Angle
27	172.7692701	0.0198625	-0.0150050	-0.0197045	Yes	1 x 30° Angle
28	171.8549736	0.0176455	-0.0150050	-0.0174675	Yes	1 x 30° Angle
29	187.1780498	0.0200075	-0.0200050	-0.0198507	Yes	1 x 30° Angle

Vertex No.	Angle (degree)	Hypoth (m)	X value (m)	Y value (m)	Value Change?	To Change
30	172.8219502	0.0200075	-0.0150050	-0.0198507	Yes	1 x 30° Angle
31	248.1450264	0.0176455	-0.0338823	-0.0065687	Yes	1 x 30° Angle
32	247.2307299	0.0198625	-0.0358196	-0.0076872	Yes	1 x 30° Angle
33	232.7692701	0.0198625	-0.0333196	-0.0120173	Yes	1 x 30° Angle
34	231.8549736	0.0176455	-0.0313823	-0.0108988	Yes	1 x 30° Angle
35	247.1780498	0.0200075	-0.0359462	-0.0077603	Yes	1 x 30° Angle
36	232.8219502	0.0200075	-0.0334462	-0.0120904	Yes	1 x 30° Angle
37	308.1450264	0.0176455	-0.0313823	0.0108988	Yes	1 x 30° Angle
38	307.2307299	0.0198625	-0.0333196	0.0120173	Yes	1 x 30° Angle
39	292.7692701	0.0198625	-0.0358196	0.0076872	Yes	1 x 30° Angle
40	291.8549736	0.0176455	-0.0338823	0.0065687	Yes	1 x 30° Angle
41	307.1780498	0.0200075	-0.0334462	0.0120904	Yes	1 x 30° Angle
42	292.8219502	0.0200075	-0.0359462	0.0077603	Yes	1 x 30° Angle
43	25.0968607	0.0149675 *	0.0039506	0.0063485	Yes	Care! 1 x Angle
44	28.9642656	0.0149675 *	0.0044096	0.0072482	No	#
45	90.0000000	0.0149675 *	0.0324725	0.0000000	No	#
46	90.0000000	0.0200075 *	0.0375125	0.0000000	No	#
47	-28.9642656	0.0149675 *	0.0044096	-0.0072482	No	#
48	-25.0968607	0.0149675 *	0.0039506	-0.0063485	Yes	Care! 1 x Angle

Appendix Z:

Macro-Element Numbering Schemes Assigned to Each of the Set 2, 2D Mixing Disc Meshes.



Mixing discs - $\alpha = 25° - 30°$ APPENDIX AA

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
1	1 = 2	Straight	#	#	#	*	*12*	Cheb	Twrds Both Extrms	Prop. Ch. B.	120
	2 = 3	Circular	0.0198625	Left	Right	*	*10*	Cheb	Twrds Both Extrms	Towards	
	3 = 4	Straight	#	#	#		12	Cheb	Twrds Both Extrms	4 = 1	
	4 = 1	Circular	0.0025001	Right	Left		10	Uniform	#		
2	2 = 5	Straight	#	#	#	*	*2*	Uniform	#	Prop. Ch. B.	20
	5 = 6	Circular	0.0200075	Left	Right		10	Cheb	Twrds Both Extrms	Towards	
	6 = 3	Straight	#	#	#		2	Uniform	#	5 = 6	
	3 = 2	#	#	#	#		10	Cheb	Twrds Both Extrms		
3	2 = 9	Circular	0.0198625	Right	Left	*	*16*	Cheb	Twrds Both Extrms	Prop. Ch. B.	32
	9 = 12	Straight	#	#	#		2	Uniform	#	Towards	
	12 = 5	Circular	0.0200075	Right	Left		16	Cheb	Twrds Both Extrms	2 = 9	
	5 = 2	#	#	#	#		2	Uniform	#		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
4	7 = 8	Straight	#	#	#	*	*12*	Cheb	Twrds Both Extrms	Prop. Ch. B.	72
	8 = 9	Circular	0.0198625	Left	Right	****	*6, 3*	Cheb	Twrds Macr Vert 9	Towards	36
	9 = 10	Straight	#	#	#		12	Cheb	Twrds Both Extrms	10 = 7	
	10 = 7	Circular	0.0025001	Right	Left		6, 3	Uniform	#		
5	8 = 11	Straight	#	#	#		2	Uniform	#	Prop. Ch. B.	12
	11 = 12	Circular	0.0200075	Left	Right		6, 3	Cheb	Twrds Macr Vert 12	Towards	6
	12 = 9	#	#	#	#		2	Uniform	#	11 = 12	
	9 = 8	#	#	#	#		6, 3	Cheb	Twrds Macr Vert 9		
6	13 = 14	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Prop. Ch. B.	72
	14 = 8	Circular	0.0198625	Right	Left	****	*6, 9*	Cheb	Twrds Macr Vert 14	Towards	108
	8 = 7	#	#	#	#		12	Cheb	Twrds Both Extrms	7 = 13	
	7 = 13	Circular	0.0025001	Left	Right		6, 9	Uniform	#		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
7	14 = 15	Straight	#	#	#		2	Uniform	#	Prop. Ch. B.	12
	15 = 11	Circular	0.0200075	Right	Left		6, 9	Cheb	Twrds Macr Vert 15	Towards	18
	11 = 8	#	#	#	#		2	Uniform	#	15 = 11	
	8 = 14	#	#	#	#		6, 9	Cheb	Twrds Both Extrms		
8	14 = 18	Circular	0.0198625	Right	Left	*	*30*	Cheb	Twrds Both Extrms	Prop. Ch. B.	60
	18 = 21	Straight	#	#	#		2	Uniform	#	Towards	
	21 = 15	Circular	0.0200075	Right	Left		30	Cheb	Twrds Both Extrms	14 = 18	
	15 = 14	#	#	#	#		2	Uniform	#		
9	16 = 17	Straight	#	#	#	*	*12*	Cheb	Twrds Both Extrms	Prop. Ch. B.	72
	17 = 18	Circular	0.0198625	Left	Right	****	*6, 3*	Cheb	Twrds Macr Vert 18	Towards	36
	18 = 19	Straight	#	#	#		12	Cheb	Twrds Both Extrms	19 = 16	
	19 = 16	Circular	0.0025001	Right	Left		6, 3	Uniform	#		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
10	17 = 20	Straight	#	#	#		2	Uniform	#	Prop. Ch. B.	12
	20 = 21	Circular	0.0200075	Left	Right		6, 3	Cheb	Twrds Macr Vert 21	Towards	6
	21 = 18	#	#	#	#		2	Uniform	#	20 = 21	
	18 = 17	#	#	#	#		6, 3	Cheb	Twrds Both Extrms		
11	22 = 23	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Prop. Ch. B.	72
	23 = 17	Circular	0.0198625	Right	Left	****	6, 9	Cheb	Twrds Macr Vert 23	Towards	108
	17 = 16	#	#	#	#		12	Cheb	Twrds Both Extrms	16 = 22	
	16 = 22	Circular	0.0025001	Left	Right		6, 9	Uniform	#		
12	23 = 24	Straight	#	#	#		2	Uniform	#	Prop. Ch. B.	12
	24 = 20	Circular	0.0200075	Right	Left		6, 9	Cheb	Twrds Macr Vert 24	Towards	18
	20 = 17	#	#	#	#		2	Uniform	#	24 = 20	
	17 = 23	#	#	#	#		6, 9	Cheb	Twrds Both Extrms		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
13	23 = 27	Circular	0.0198625	Right	Left	*	*16*	Cheb	Twrds Both Extrms	Prop. Ch. B.	32
	27 = 30	Straight	#	#	#		2	Uniform	#	Towards	
	30 = 24	Circular	0.0200075	Left	Right		16	Cheb	Twrds Both Extrms	23 = 27	
	24 = 23	#	#	#	#		2	Uniform	#		
14	25 = 26	Straight	#	#	#	*	*12*	Cheb	Twrds Both Extrms	Prop. Ch. B.	120
	26 = 27	Circular	0.0198625	Left	Right	*	*10*	Cheb	Twrds Both Extrms	Towards	
	27 = 28	Straight	#	#	#		12	Cheb	Twrds Both Extrms	28 = 25	
	28 = 25	Circular	0.0025001	Right	Left		10	Uniform	#		
15	26 = 29	Straight	#	#	#		2	Uniform	#	Prop. Ch. B.	20
	29 = 30	Circular	0.0200075	Left	Right		10	Cheb	Twrds Both Extrms	Towards	
	30 = 27	#	#	#	#		2	Uniform	#	29 = 30	
	27 = 26	#	#	#	#		10	Cheb	Twrds Both Extrms		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
16	26 = 33	Circular	0.0198625	Right	Left	*	***16***	Cheb	Twrds Both Extrms	Prop. Ch. B.	32
	33 = 36	Straight	#	#	#		2	Uniform	#	Towards	
	36 = 29	Circular	0.0200075	Right	Left		16	Cheb	Twrds Both Extrms	26 = 33	
	29 = 26	#	#	#	#		2	Uniform	#		
17	31 = 32	Straight	#	#	#	*	***12***	Cheb	Twrds Both Extrms	Prop. Ch. B.	120
	32 = 33	Circular	0.0198625	Left	Right	*	***10***	Cheb	Twrds Both Extrms	Towards	
	33 = 34	Straight	#	#	#		12	Cheb	Twrds Both Extrms	34 = 31	
	34 = 31	Circular	0.0025001	Right	Left		10	Uniform	#		
18	32 = 35	Straight	#	#	#		2	Uniform	#	Prop. Ch. B.	20
	35 = 36	Circular	0.0200075	Left	Right		10	Cheb	Twrds Both Extrms	Towards	
	36 = 33	#	#	#	#		2	Uniform	#	35 = 36	
	33 = 32	#	#	#	#		10	Cheb	Twrds Both Extrms		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
19	32 = 39	Circular	0.0198625	Right	Left	*	***16***	Cheb	Twrds Both Extrms	Prop. Ch. B.	32
	39 = 42	Straight	#	#	#		2	Uniform	#	Towards	
	42 = 35	Circular	0.0200075	Right	Left		16	Cheb	Twrds Both Extrms	32 = 39	
	35 = 32	#	#	#	#		2	Uniform	#		
20	37 = 38	Straight	#	#	#	*	***12***	Cheb	Twrds Both Extrms	Prop. Ch. B.	120
	38 = 39	Circular	0.0198625	Left	Right	*	***10***	Cheb	Twrds Both Extrms	Towards	
	39 = 40	Straight	#	#	#		12	Cheb	Twrds Both Extrms	40 = 37	
	40 = 37	Circular	0.0025001	Right	Left		10	Uniform	#		
21	38 = 41	Straight	#	#	#		2	Uniform	#	Prop. Ch. B.	20
	41 = 42	Circular	0.0200075	Left	Right		10	Cheb	Twrds Both Extrms	Towards	
	42 = 39	#	#	#	#		2	Uniform	#	41 = 42	
	39 = 38	#	#	#	#		10	Cheb	Twrds Both Extrms		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
22	38 = 3	Circular	0.0198625	Left	Right	*	*16*	Cheb	Twrds Both Extrms	Prop. Ch. B.	32
	3 = 6	#	#	#	#		2	Uniform	#	Towards	
	6 = 41	Circular	0.0200075	Left	Right		16	Cheb	Twrds Both Extrms	38 = 3	
	41 = 38	#	#	#	#		2	Uniform	#		
23	43 = 44	Circular	0.0149675	Right	Left		6, 9	Cheb	Twrds Macr Vert 43	Prop. Ch. B.	72
	44 = 11	Straight	#	#	#	*	*12*	Cheb	Twrds Both Extrms	Towards	108
	11 = 15	#	#	#	#		6, 9	Cheb	Twrds Macr Vert 15	43 = 44	
	15 = 43	Straight	#	#	#		12	Cheb	Twrds Both Extrms		
24	44 = 45	Circular	0.0149675	Right	Left	*	*40*	Cheb	Twrds Macr Vert 44	Prop. Ch. B.	480
	45 = 46	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	
	46 = 11	Circular	0.0200075	Right	Left		40	Cheb	Twrds Macr Vert 11	44 = 45	
	11 = 44	#	#	#	#		12	Cheb	Twrds Both Extrms		

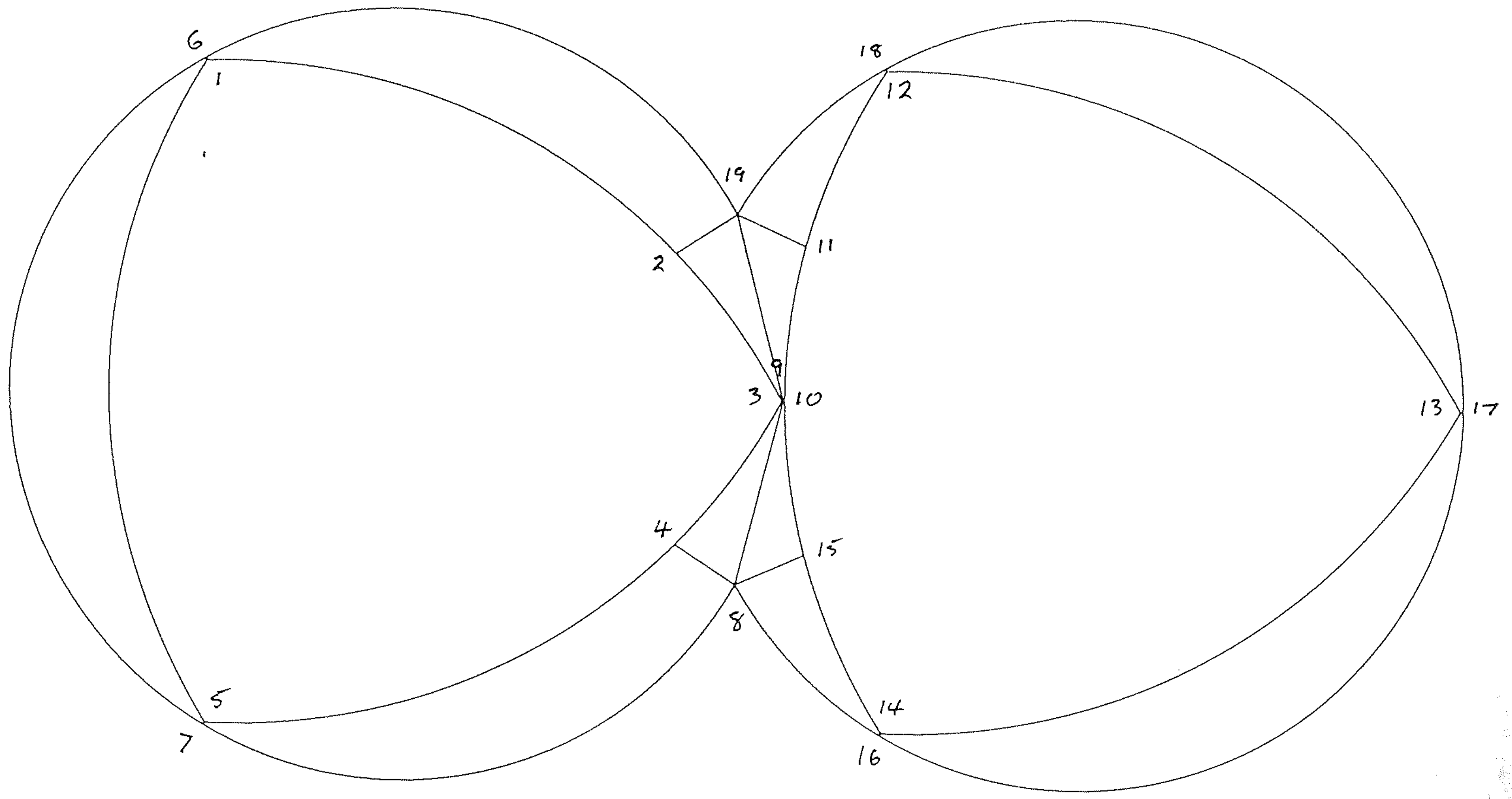
Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
25	45 = 47	Circular	0.0149675	Right	Left	*	*40*	Cheb	Twrds Macr Vert 47	Prop. Ch. B.	480
	47 = 20	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	
	20 = 46	Circular	0.0200075	Left	Right		40	Cheb	Twrds Macr Vert 20	45 = 47	
	46 = 45	#	#	#	#		12	Cheb	Twrds Both Extrms		
26	47 = 48	Circular	0.0149675	Right	Left		6, 3	Cheb	Twrds Macr Vert 48	Prop. Ch. B.	72
	48 = 21	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	36
	21 = 20	#	#	#	#		6, 3	Cheb	Twrds Macr Vert 21	47 = 48	
	20 = 47	#	#	#	#		12	Cheb	Twrds Both Extrms		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
27	48 = 43	Circular	0.0149675	Left	Right		30	Cheb	Twrds Both Extrms	Prop. Ch. B.	360
	43 = 15	#	#	#	#		12	Cheb	Twrds Both Extrms	Towards	
	15 = 21	#	#	#	#		30	Cheb	Twrds Both Extrms	48 = 43	
	21 = 48	#	#	#	#		12	Cheb	Twrds Both Extrms		
								**** - Represents		Total =	2580
								Progress Between Values			2580
								Shown For Each 5° Rotation			

Appendix AB: Boundary Numbering Scheme Used for Each of the Set 2, 2D Mixing Disc Meshes.

Bound No.	Left CICo-TSE Element: 1 Start	(Direction)	1 End	Right CICo-TSE Element: 2 Start	(Direction)	2 End	Outer Barrel Wall: 3 Start	(Direction)	3 End
	1	(=> 2)	1	43	(=> 44)	43	11	(=> 12)	11

Appendix AC:
Macro-Vertex Numbering Scheme Assigned to Meshes Pertaining to Set 1 Representations of the 2D Trilobal Elements.



APPENDIX AD1

Trilobe Element - $\alpha = 0°$

* = Right hand screw

Vertex No.	Angle (degree)	Hypoth (m)		X value (m)	Y value (m)	Value Change?	To Change
1	330.0000000	0.0198625		-0.0274363	0.0172014	Yes	1 x 0° Angle
2	61.0357344	0.0173775		-0.0030952	0.0076354	Yes	1 x 0° Angle
3	90.0000000	0.0198625		0.0023575	0.0000000	Yes	1 x 0° Angle
4	118.9642656	0.0173775		-0.0030952	-0.0076354	Yes	1 x 0° Angle
5	210.0000000	0.0198625		-0.0274363	-0.0172014	Yes	1 x 0° Angle
6	330.0000000	0.0200075		-0.0275088	0.0173270	Yes	1 x 0° Angle
7	210.0000000	0.0200075		-0.0275088	-0.0173270	Yes	1 x 0° Angle
8	118.9642656	0.0200075		0.0000000	-0.0096889	No	#
9	90.0000000	0.0199375		0.0024325	0.0000000	Yes	1 x 0° Angle
10	#	#	*	0.0025075	0.0000000	Yes	No. 3 coords
11	61.0357344	0.0173775	*	0.0035362	0.0080963	Yes	1 x 0° Angle
12	330.0000000	0.0198625	*	0.0075737	0.0172014	Yes	1 x 0° Angle
13	90.0000000	0.0198625	*	0.0373675	0.0000000	Yes	1 x 0° Angle
14	210.0000000	0.0198625	*	0.0075738	-0.0172014	Yes	1 x 0° Angle
15	118.9642656	0.0173775	*	0.0035362	-0.0080963	Yes	1 x 0° Angle
16	210.0000000	0.0200075	*	0.0075013	-0.0173270	Yes	1 x 0° Angle
17	90.0000000	0.0200075	*	0.0375125	0.0000000	Yes	1 x 0° Angle
18	330.0000000	0.0200075	*	0.0075012	0.0173270	Yes	1 x 0° Angle
19	61.0357344	0.0200075		0.0000000	0.0096889	No	#

APPENDIX A02

Trilobe Element - $\alpha = 5°$

* = Right hand screw

Vertex No.	Angle (degree)	Hypoth (m)		X value (m)	Y value (m)	Value Change?	To Change
1	325.0000000	0.0198625		-0.0288977	0.0162704	Yes	1 x 5° Angle
2	61.0357344	0.0173775		-0.0027620	0.0079213	Yes	1 x 5° Angle
3	85.0000000	0.0198625		0.0022819	0.0017311	Yes	1 x 5° Angle
4	118.9642656	0.0173775		-0.0034063	-0.0074208	Yes	1 x 5° Angle
5	205.0000000	0.0198625		-0.0258993	-0.0180015	Yes	1 x 5° Angle
6	325.0000000	0.0200075		-0.0289808	0.0163892	Yes	1 x 5° Angle
7	205.0000000	0.0200075		-0.0259605	-0.0181330	Yes	1 x 5° Angle
8	118.9642656	0.0200075		0.0000000	-0.0096889	No	#
9	85.0000000	0.0199378		0.0023569	0.0017377	Yes	1 x 5° Angle
10	#	#	*	0.0024319	0.0017311	Yes	No. 3 coords
11	61.0357344	0.0173775	*	0.0031467	0.0082358	Yes	1 x 5° Angle
12	325.0000000	0.0198625	*	0.0061123	0.0162704	Yes	1 x 5° Angle
13	85.0000000	0.0198625	*	0.0372919	0.0017311	Yes	1 x 5° Angle
14	205.0000000	0.0198625	*	0.0091107	-0.0180015	Yes	1 x 5° Angle
15	118.9642656	0.0173775	*	0.0038531	-0.0079413	Yes	1 x 5° Angle
16	205.0000000	0.0200075	*	0.0090495	-0.0181330	Yes	1 x 5° Angle
17	85.0000000	0.0200075	*	0.0374364	0.0017438	Yes	1 x 5° Angle
18	325.0000000	0.0200075	*	0.0060292	0.0163892	Yes	1 x 5° Angle
19	61.0357344	0.0200075		0.0000000	0.0096889	No	#

APPENDIX AD3

Trilobe Element - $\alpha = 10°$

* = Right hand screw

Vertex No.	Angle (degree)	Hypoth (m)		X value (m)	Y value (m)	Value Change?	To Change
1	320.0000000	0.0198625		-0.0302724	0.0152156	Yes	1 x 10° Angle
2	61.0357344	0.0173775		-0.0024149	0.0082821	Yes	1 x 10° Angle
3	80.0000000	0.0198625		0.0020557	0.0034491	Yes	1 x 10° Angle
4	118.9642656	0.0173775		-0.0036873	-0.0072733	Yes	1 x 10° Angle
5	200.0000000	0.0198625		-0.0242984	-0.0186646	Yes	1 x 10° Angle
6	320.0000000	0.0200075		-0.0303656	0.0153266	Yes	1 x 10° Angle
7	200.0000000	0.0200075		-0.0243480	-0.0188009	Yes	1 x 10° Angle
8	118.9642656	0.0200075		0.0000000	-0.0096889	No	#
9	80.0000000	0.0199387		0.0021307	0.0034623	Yes	1 x 10° Angle
10	#	#	*	0.0022057	0.0034491	Yes	No. 3 coords
11	61.0357344	0.0173775	*	0.0026858	0.0083510	Yes	1 x 10° Angle
12	320.0000000	0.0198625	*	0.0047376	0.0152156	Yes	1 x 10° Angle
13	80.0000000	0.0198625	*	0.0370657	0.0034491	Yes	1 x 10° Angle
14	200.0000000	0.0198625	*	0.0107116	-0.0186646	Yes	1 x 10° Angle
15	118.9642656	0.0173775	*	0.0040971	-0.0077799	Yes	1 x 10° Angle
16	200.0000000	0.0200075	*	0.0106620	-0.0188009	Yes	1 x 10° Angle
17	80.0000000	0.0200075	*	0.0372085	0.0034743	Yes	1 x 10° Angle
18	320.0000000	0.0200075	*	0.0046444	0.0153266	Yes	1 x 10° Angle
19	61.0357344	0.0200075		0.0000000	0.0096889	No	#

APPENDIX AD4

Trilobe Element - $\alpha = 15°$ * = Right hand screw

Vertex No.	Angle (degree)	Hypoth (m)		X value (m)	Y value (m)	Value Change?	To Change
1	315.0000000	0.0198625		-0.0315499	0.0140449	Yes	1 x 15° Angle
2	61.0357344	0.0173775		-0.0020626	0.0087203	Yes	1 x 15° Angle
3	75.0000000	0.0198625		0.0016807	0.0051408	Yes	1 x 15° Angle
4	118.9642656	0.0173775		-0.0039308	-0.0071879	Yes	1 x 15° Angle
5	195.0000000	0.0198625		-0.0226458	-0.0191857	Yes	1 x 15° Angle
6	315.0000000	0.0200075		-0.0316524	0.0141474	Yes	1 x 15° Angle
7	195.0000000	0.0200075		-0.0226833	-0.0193258	Yes	1 x 15° Angle
8	118.9642656	0.0200075		0.0000000	-0.0096889	No	#
9	75.0000000	0.0199401		0.0017557	0.0051609	Yes	1 x 15° Angle
10	#	#	*	0.0018307	0.0051408	Yes	No. 3 coords
11	61.0357344	0.0173775	*	0.0021555	0.0084331	Yes	1 x 15° Angle
12	315.0000000	0.0198625	*	0.0034601	0.0140449	Yes	1 x 15° Angle
13	75.0000000	0.0198625	*	0.0366907	0.0051408	Yes	1 x 15° Angle
14	195.0000000	0.0198625	*	0.0123642	-0.0191857	Yes	1 x 15° Angle
15	118.9642656	0.0173775	*	0.0042690	-0.0076209	Yes	1 x 15° Angle
16	195.0000000	0.0200075	*	0.0123267	-0.0193258	Yes	1 x 15° Angle
17	75.0000000	0.0200075	*	0.0368308	0.0051783	Yes	1 x 15° Angle
18	315.0000000	0.0200075	*	0.0033576	0.0141474	Yes	1 x 15° Angle
19	61.0357344	0.0200075		0.0000000	0.0096889	No	#

APPENDIX AD5

Trilobe Element - $\alpha = 20°$ * = Right hand screw

Vertex No.	Angle (degree)	Hypoth (m)		X value (m)	Y value (m)	Value Change?	To Change
1	310.0000000	0.0198625		-0.0327206	0.0127674	Yes	1 x 20° Angle
2	61.0357344	0.0173775		-0.0017141	0.0092376	Yes	1 x 20° Angle
3	70.0000000	0.0198625		0.0011596	0.0067934	Yes	1 x 20° Angle
4	118.9642656	0.0173775		-0.0041301	-0.0071590	Yes	1 x 20° Angle
5	190.0000000	0.0198625		-0.0209541	-0.0195607	Yes	1 x 20° Angle
6	310.0000000	0.0200075		-0.0328316	0.0128606	Yes	1 x 20° Angle
7	190.0000000	0.0200075		-0.0209793	-0.0197035	Yes	1 x 20° Angle
8	118.9642656	0.0200075		0.0000000	-0.0096889	No	#
9	70.0000000	0.0199423		0.0012346	0.0068207	Yes	1 x 20° Angle
10	#	#	*	0.0013096	0.0067934	Yes	No. 3 coords
11	61.0357344	0.0173775	*	0.0015585	0.0084735	Yes	1 x 20° Angle
12	310.0000000	0.0198625	*	0.0022894	0.0127674	Yes	1 x 20° Angle
13	70.0000000	0.0198625	*	0.0361696	0.0067934	Yes	1 x 20° Angle
14	190.0000000	0.0198625	*	0.0140559	-0.0195607	Yes	1 x 20° Angle
15	118.9642656	0.0173775	*	0.0043703	-0.0074731	Yes	1 x 20° Angle
16	190.0000000	0.0200075	*	0.0140307	-0.0197035	Yes	1 x 20° Angle
17	70.0000000	0.0200075	*	0.0363059	0.0068430	Yes	1 x 20° Angle
18	310.0000000	0.0200075	*	0.0021784	0.0128606	Yes	1 x 20° Angle
19	61.0357344	0.0200075		0.0000000	0.0096889	No	#

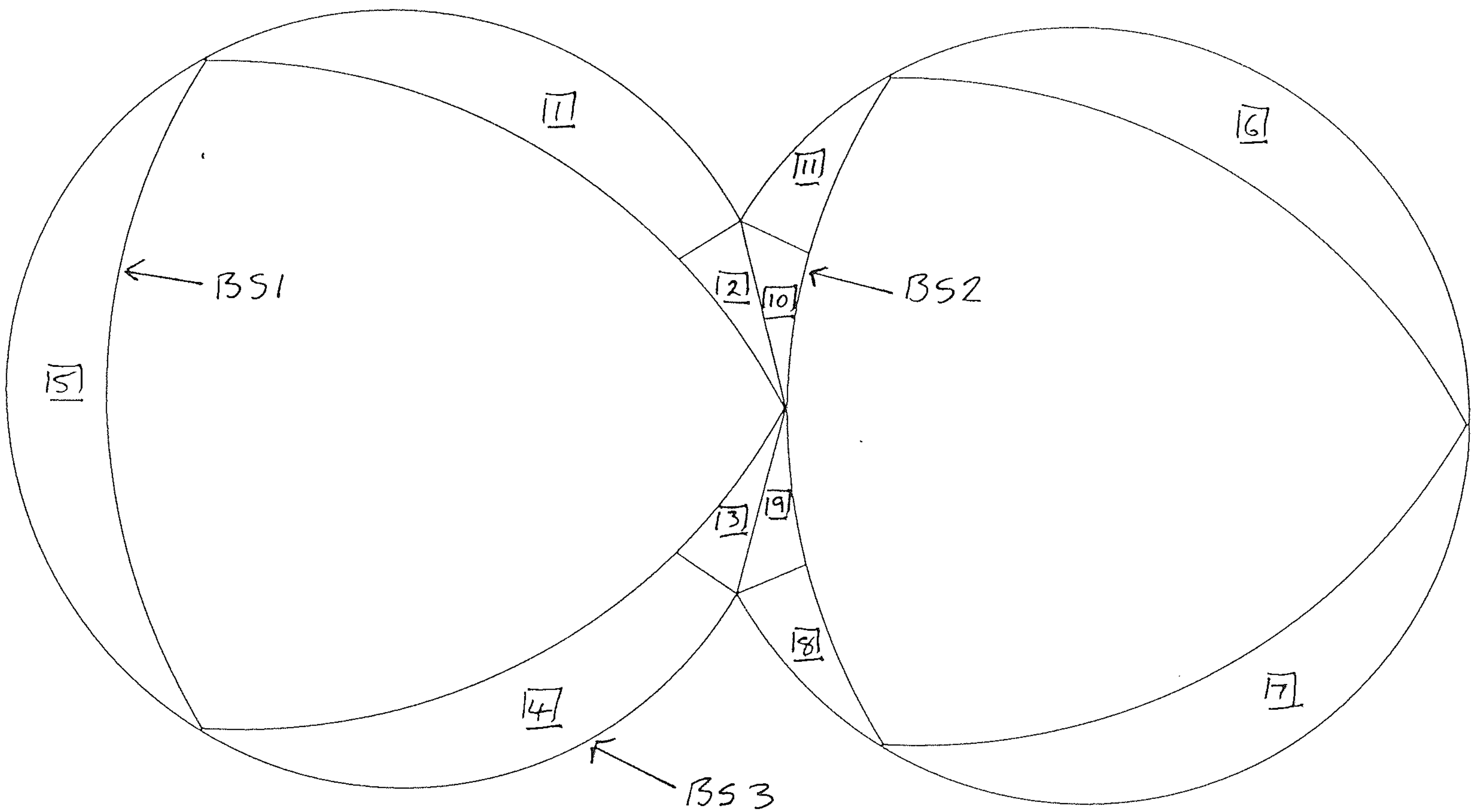
APPENDIX AD6

Trilobe Element - $\alpha = 25°$ * = Right hand screw

Vertex No.	Angle (degree)	Hypoth (m)		X value (m)	Y value (m)	Value Change?	To Change
1	305.0000000	0.0198625		-0.0337754	0.0113927	Yes	1 x 25° Angle
2	61.0357344	0.0173775		-0.0013784	0.0098351	Yes	1 x 25° Angle
3	65.0000000	0.0198625		0.0004965	0.0083943	Yes	1 x 25° Angle
4	118.9642656	0.0173775		-0.0042789	-0.0071802	Yes	1 x 25° Angle
5	185.0000000	0.0198625		-0.0192361	-0.0197869	Yes	1 x 25° Angle
6	305.0000000	0.0200075		-0.0338942	0.0114758	Yes	1 x 25° Angle
7	185.0000000	0.0200075		-0.0192488	-0.0199314	Yes	1 x 25° Angle
8	118.9642656	0.0200075		0.0000000	-0.0096889	No	#
9	65.0000000	0.0199453		0.0005715	0.0084292	Yes	1 x 25° Angle
10	#	#	*	0.0006465	0.0083943	Yes	No. 3 coords
11	61.0357344	0.0173775	*	0.0008987	0.0084638	Yes	1 x 25° Angle
12	305.0000000	0.0198625	*	0.0012346	0.0113927	Yes	1 x 25° Angle
13	65.0000000	0.0198625	*	0.0355065	0.0083943	Yes	1 x 25° Angle
14	185.0000000	0.0198625	*	0.0157739	-0.0197869	Yes	1 x 25° Angle
15	118.9642656	0.0173775	*	0.0044034	-0.0073449	Yes	1 x 25° Angle
16	185.0000000	0.0200075	*	0.0157612	-0.0199314	Yes	1 x 25° Angle
17	65.0000000	0.0200075	*	0.0356380	0.0084555	Yes	1 x 25° Angle
18	305.0000000	0.0200075	*	0.0011158	0.0114758	Yes	1 x 25° Angle
19	61.0357344	0.0200075		0.0000000	0.0096889	No	#

Appendix AE:

Macro-Element Numbering Schemes Assigned to Each of the Set 1, 2D Trilobal Element Meshes.



Trilobal Element - $\alpha = 0° - 25°$ APPENDIX AF

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
1	1 = 2	Circular	0.0323750	Right	Left	****	*34 to 44*	Uniform	#	Prop. Ch. B.	408
	2 = 19	Straight	#	#	#	*	*12*	Cheb	Twrds Both Extrms	Towards	528
	19 = 16	Circular	0.0200075	Right	Left		34 to 44	Uniform	#	1 = 2	
	6 = 1	Straight	#	#	#		12	Cheb	Twrds Both Extrms		
2	2 = 3	Circular	0.0323750	Right	Left	****	*12 to 2*	Uniform	#	Prop. Ch. B.	144
	3 = 9	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	24
	9 = 19	Straight	#	#	#		12 to 2	Uniform	#	2 = 3	
	19 = 2	#	#	#	#		12	Cheb	Twrds Both Extrms		
3	3 = 4	Circular	0.0323750	Right	Left	****	*12 to 22*	Uniform	#	Prop. Ch. B.	144
	4 = 8	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	264
	8 = 9	Straight	#	#	#		12 to 22	Uniform	#	3 = 4	
	9 = 3	#	#	#	#		12	Cheb	Twrds Both Extrms		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
4	4 = 5	Circular	0.0323750	Right	Left	****	*34 to 24*	Uniform	#	Prop. Ch. B.	408
	5 = 7	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	288
	7 = 8	Circular	0.0200075	Left	Right		34 to 24	Uniform	#	4 = 5	
	8 = 4	#	#	#	#		12	Cheb	Twrds Both Extrms		
5	5 = 1	Circular	0.0323750	Left	Right	*	*46*	Uniform	#	Prop. Ch. B.	552
	1 = 6	#	#	#	#		12	Cheb	Twrds Both Extrms	Towards	
	6 = 7	Circular	0.0200075	Left	Right		46	Uniform	#	5 = 1	
	7 = 5	#	#	#	#		12	Cheb	Twrds Both Extrms		
6	12 = 13	Circular	0.0323750	Right	Left	*	*46*	Uniform	#	Prop. Ch. B.	552
	13 = 17	Straight	#	#	#	*	*12*	Cheb	Twrds Both Extrms	Towards	
	17 = 18	Circular	0.0200075	Left	Right		46	Uniform	#	12 = 13	
	18 = 12	Straight	#	#	#		12	Cheb	Twrds Both Extrms		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
7	13 = 14	Circular	0.0323750	Right	Left	*	*46*	Uniform	#	Prop. Ch. B.	552
	14 = 16	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	
	16 = 17	Circular	0.0200075	Left	Right		46	Uniform	#	13 = 14	
	17 = 13	#	#	#	#		12	Cheb	Twrds Both Extrms		
8	14 = 15	Circular	0.0323750	Right	Left	****	*14 to 24*	Uniform	#	Prop. Ch. B.	168
	15 = 8	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	288
	8 = 16	Circular	0.0200075	Left	Right		14 to 24	Uniform	#	14 = 15	
	16 = 14	#	#	#	#		12	Cheb	Twrds Both Extrms		
9	15 = 10	Circular	0.0323750	Left	Right	****	*12 to 22*	Uniform	#	Prop. Ch. B.	144
	10 = 9	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	264
	9 = 8	#	#	#	#		12 to 22	Uniform	#	15 = 10	
	8 = 15	#	#	#	#		12	Cheb	Twrds Both Extrms		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
10	10 = 11	Circular	0.0323750	Right	Left	****	*12 to 2*	Uniform	#	Prop. Ch. B.	144
	11 = 19	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	24
	19 = 9	#	#	#	#		12 to 2	Uniform	#	10 = 11	
	9 = 10	#	#	#	#		12	Cheb	Twrds Both Extrms		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
11	11 = 12	Circular	0.0323750	Right	Left	****	*14 to 4*	Uniform	#	Prop. Ch. B.	168
	12 = 18	#	#	#	#		12	Cheb	Twrds Both Extrms	Towards	48
	18 = 19	Circular	0.0200075	Left	Right		14 to 4	Uniform	#	11 = 12	
	19 = 11	#	#	#	#		12	Cheb	Twrds Both Extrms		

**** - Represents Progress Between Values Shown For Each 5° Rotation

Total = 3384

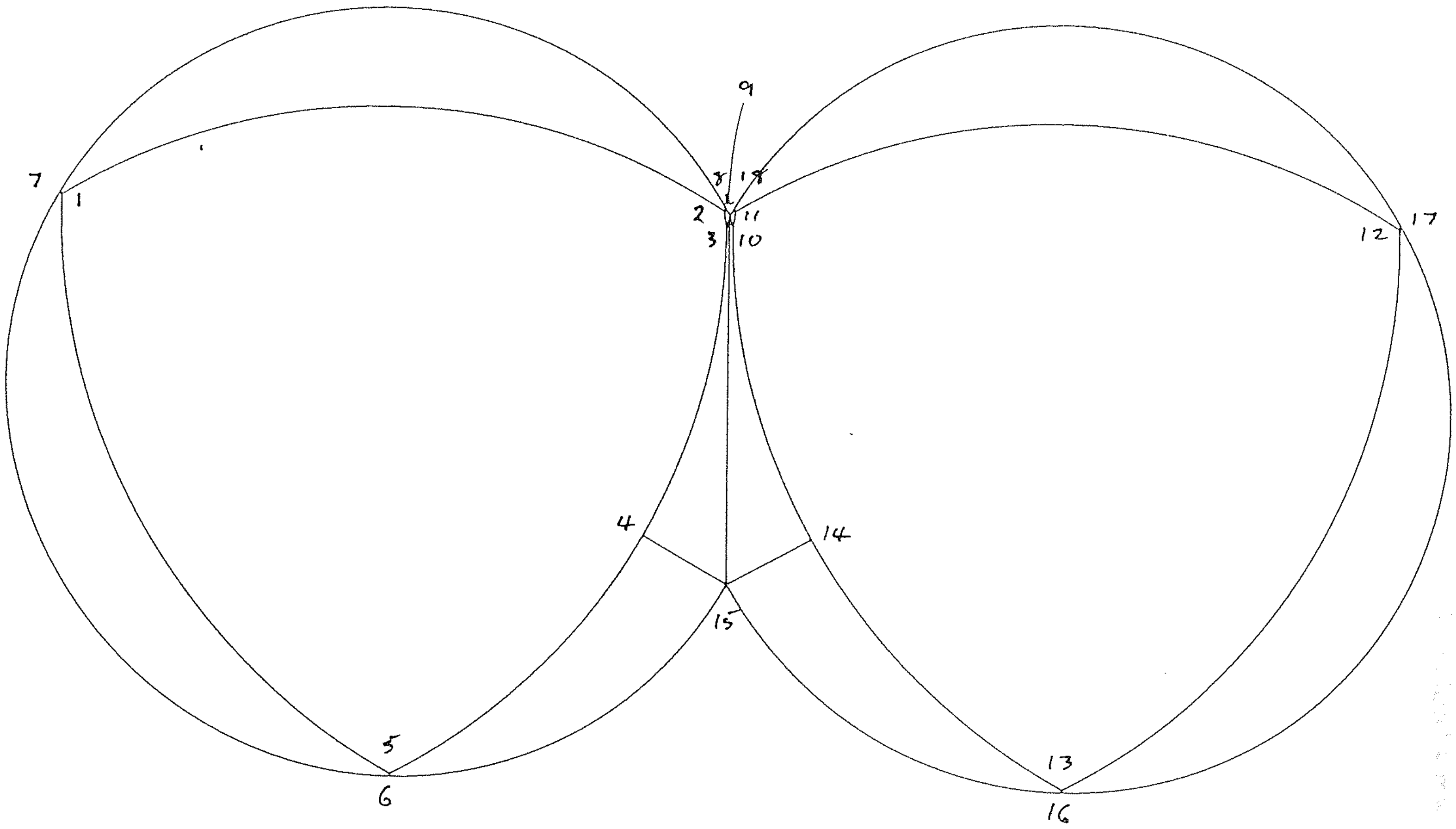
Total = 3384

Appendix AG: Boundary Numbering Scheme Used for Each of the Set 1, 2D Trilobal Element Meshes.

Bound No.	Left CICo-TSE Element Start	(Direction)	Left CICo-TSE Element End	Right CICo-TSE Element Start	(Direction)	Right CICo-TSE Element End	Outer Barrel Wall Start	(Direction)	Outer Barrel Wall End
	1		1	2		2	3		3
	1	(=> 2)	1	10	(=> 11)	10	19	(=> 6)	19

Appendix AH:

Macro-Vertex Numbering Scheme Assigned to the Mesh Pertaining to the Set 2 Representation of the 2D Trilobal Elements.



APPENDIX AI

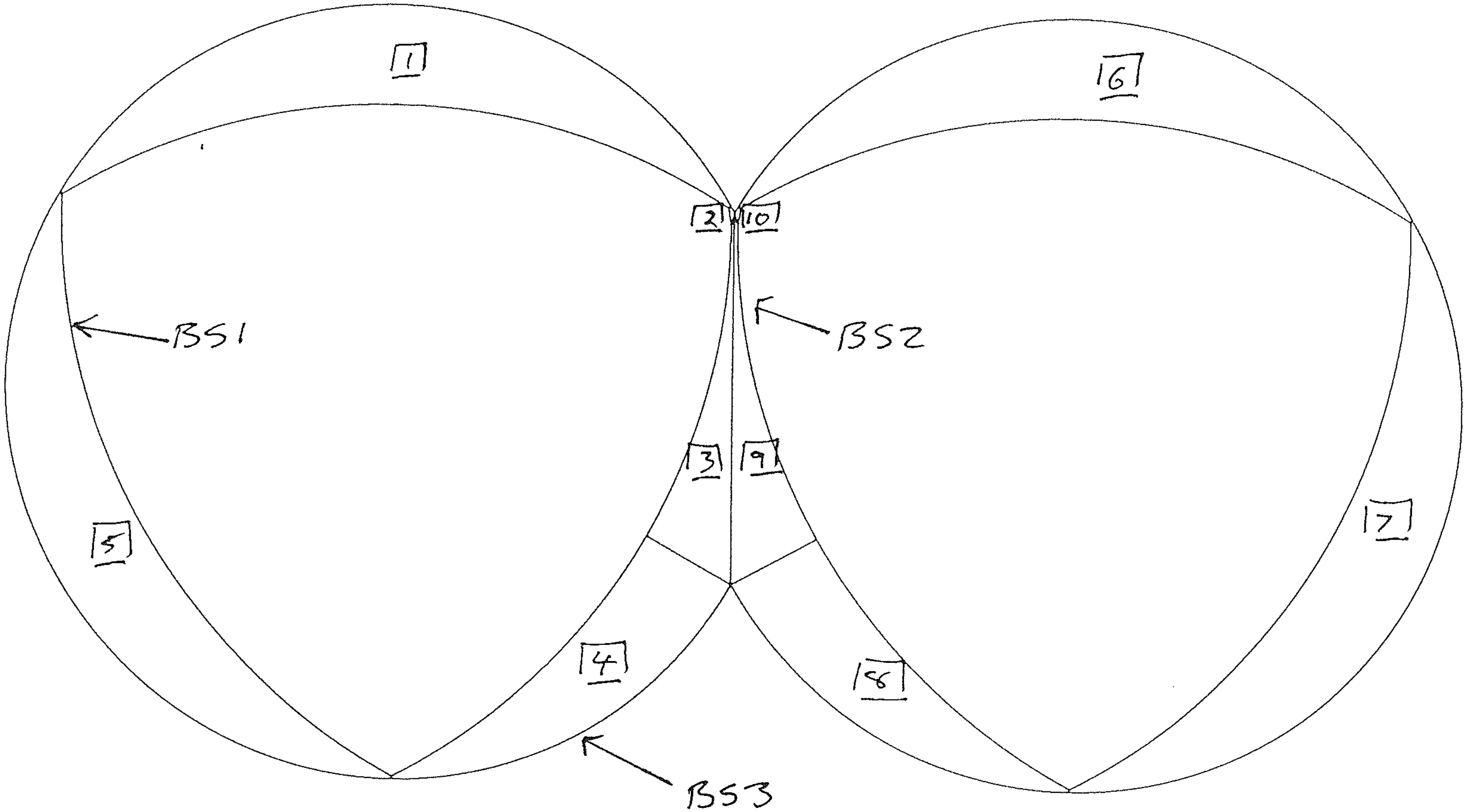
Trilobe Element - $\alpha = 30°$

* = Right hand screw

Vertex No.	Angle (degree)	Hypoth (m)		X value (m)	Y value (m)	Value Change?	To Change
1	300.0000000	0.0198625		-0.0347064	0.0099313	Yes	1 x 30° Angle
2	60.0000000	0.0198625		-0.0003036	0.0099313	Yes	1 x 30° Angle
3	61.0357344	0.0173775		-0.0001807	0.0089814	Yes	1 x 30° Angle
4	118.9642656	0.0173775		-0.0043716	-0.0072447	Yes	1 x 30° Angle
5	180.0000000	0.0198625		-0.0175050	-0.0198625	Yes	1 x 30° Angle
6	180.0000000	0.0200075		-0.0175050	-0.0200075	Yes	1 x 30° Angle
7	300.0000000	0.0200075		-0.0348320	0.0100038	Yes	1 x 30° Angle
8	60.0000000	0.0200075		-0.0001780	0.0100038	Yes	1 x 30° Angle
9	61.0357344	0.0200075		0.0000000	0.0096889	No	#
10	61.0357344	0.0173775	*	0.0001807	0.0089814	Yes	1 x 30° Angle
11	300.0000000	0.0198625	*	0.0003036	0.0099313	Yes	1 x 30° Angle
12	60.0000000	0.0198625	*	0.0347064	0.0099313	Yes	1 x 30° Angle
13	180.0000000	0.0198625	*	0.0175050	-0.0198625	Yes	1 x 30° Angle
14	118.9642656	0.0173775	*	0.0043716	-0.0072447	Yes	1 x 30° Angle
15	118.9642656	0.0200075		0.0000000	-0.0096889	No	#
16	180.0000000	0.0200075	*	0.0175050	-0.0200075	Yes	1 x 30° Angle
17	60.0000000	0.0200075	*	0.0348320	0.0100038	Yes	1 x 30° Angle
18	300.0000000	0.0200075	*	0.0001780	0.0100038	Yes	1 x 30° Angle

Appendix AJ:

Macro-Element Numbering Scheme Assigned to the 2D Trilobal Element Mesh Pertaining to Set 2.



Trilobal Element - $\alpha = 30°$ APPENDIX AK

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
1	1 = 2	Circular	0.0323750	Right	Left	*	*46*	Uniform	#	Prop. Ch. B.	552
	2 = 8	Straight	#	#	#	*	*12*	Cheb	Twrds Both Extrms	Towards	
	8 = 7	Circular	0.0200075	Right	Left		46	Uniform	#	1 = 2	
	7 = 1	Straight	#	#	#		12	Cheb	Twrds Both Extrms		
2	2 = 3	Circular	0.0323750	Right	Left	*	*2*	Uniform	#	Prop. Ch. B.	24
	3 = 9	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	
	9 = 8	Circular	0.0200075	Right	Left		2	Uniform	#	2 = 3	
	8 = 2	#	#	#	#		12	Cheb	Twrds Both Extrms		
3	3 = 4	Circular	0.0323750	Right	Left	*	*23*	Uniform	#	Prop. Ch. B.	276
	4 = 15	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	
	15 = 9	Straight	#	#	#		23	Uniform	#	3 = 4	
	9 = 3	#	#	#	#		12	Cheb	Twrds Both Extrms		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
4	4 = 5	Circular	0.0323750	Right	Left	*	***24***	Uniform	#	Prop. Ch. B.	288
	5 = 6	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	
	6 = 15	Circular	0.0200075	Left	Right		24	Uniform	#	4 = 5	
	15 = 4	#	#	#	#		12	Cheb	Twrds Both Extrms		
5	5 = 1	Circular	0.0323750	Left	Right	*	***46***	Uniform	#	Prop. Ch. B.	552
	1 = 7	#	#	#	#		12	Cheb	Twrds Both Extrms	Towards	
	7 = 6	Circular	0.0200075	Right	Left		46	Uniform	#	5 = 1	
	6 = 5	#	#	#	#		24	Cheb	Twrds Both Extrms		
6	11 = 12	Circular	0.0323750	Right	Left	*	***46***	Uniform	#	Prop. Ch. B.	552
	12 = 17	Straight	#	#	#	*	***12***	Cheb	Twrds Both Extrms	Towards	
	17 = 18	Circular	0.0200075	Left	Right		46	Uniform	#	11 = 12	
	18 = 11	Straight	#	#	#		12	Cheb	Twrds Both Extrms		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
7	12 = 13	Circular	0.0323750	Right	Left	*	*46*	Uniform	#	Prop. Ch. B.	552
	13 = 16	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	
	16 = 17	Circular	0.0200075	Left	Right		46	Uniform	#	12 = 13	
	17 = 12	#	#	#	#		12	Cheb	Twrds Both Extrms		
8	13 = 14	Circular	0.0323750	Right	Left	*	*24*	Uniform	#	Prop. Ch. B.	288
	14 = 15	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	
	15 = 16	Circular	0.0200075	Left	Right		24	Uniform	#	13 = 14	
	16 = 13	#	#	#	#		12	Cheb	Twrds Both Extrms		
9	14 = 10	Circular	0.0323750	Left	Right	*	*23*	Uniform	#	Prop. Ch. B.	276
	10 = 9	Straight	#	#	#		12	Cheb	Twrds Both Extrms	Towards	
	9 = 15	#	#	#	#		23	Uniform	#	14 = 10	
	15 = 14	#	#	#	#		12	Cheb	Twrds Both Extrms		

Element No.	Segment Numbering	Shape	Radius of Arc	Center	Arc Orientation	Value Change?	No. of Segments	Distribution	Conditions	Method	Total No. of Elements
10	10 = 11	Circular	0.0323750	Right	Left	*	2	Uniform	#	Prop. Ch. B.	24
	11 = 18	#	#	#	#		12	Cheb	Twrds Both Extrms	Towards	
	18 = 9	Circular	0.0200075	Right	Left		2	Uniform	#	10 = 11	
	9 = 10	#	#	#	#		12	Cheb	Twrds Both Extrms		
										Total =	3384

Appendix AL: Boundary Numbering Scheme Used for Each of the Set 2, 2D Trilobal Element Meshes.

Bound No.	Left CICo-TSE Element Start	(Direction)	Left CICo-TSE Element End	Right CICo-TSE Element Start	(Direction)	Right CICo-TSE Element End	Outer Barrel Wall Start	(Direction)	Outer Barrel Wall End
	1		1	2		2	3		3
	1	(=> 2)	1	11	(=> 12)	11	9	(=> 7)	9

APPENDIX AM 3D Parameters Table (Cont.) - Single-Flighted Conveying Screw Elements

Screw Pitch (mm)	Max Frontal Width on Main Problem	Active Variables in Main Problem	Static Variables in Main Problem	Swap Space Needed for Main Problem (MB)	Max Frontal Width on γ Problem	Active Variables in γ Problem	Static Variables in γ Problem	Swap Space Needed for γ Problem (MB)	Max Frontal Width on T Problem	Active Variables in T Problem	Static Variables in T Problem	Swap Space Needed for T Problem (MB)	Memory Size of Problem Directory (MB)
Full Fill Channel - Half Fill Channel:													
24	2358	50313	8215	809.1	914	20764	5009	130.2	1516	22482	90	286.6	10.4

APPENDIX AN

3D Parameters Table (Cont.) - Staggered Mixing Discs

Configuration ($\alpha°$)	Max Frontal Width on Main Problem	Active Variables in Main Problem	Static Variables in Main Problem	Swap Space Needed for Main Problem (MB)	Max Frontal Width on γ Problem	Active Variables in γ Problem	Static Variables in γ Problem	Swap Space Needed for γ Problem (MB)	Max Frontal Width on T Problem	Active Variables in T Problem	Static Variables in T Problem	Swap Space Needed for T Problem (MB)	Memory Size of Problem Directory (MB)
Half Pair:													
0	1161	42482	6738	347.0	447	17895	5380	59.8	750	21792	72	145.3	12.0
15	1038	40624	6496	298.4	407	17177	5230	53.9	700	21012	84	132.2	11.6
30	1294	43578	6902	394.7	482	18191	5400	83.1	798	21984	96	154.7	11.8
One Pair:													
0	3094	74894	12146	1568.1	1214	31431	8506	237.6	2058	35868	96	604.0	26.3
15	2720	72799	11857	1341.1	1027	30735	8364	198.8	1738	35196	84	503.2	26.5
30	2807	78196	12632	1487.3	1098	32655	8714	225.3	1810	37020	96	550.0	26.9

APPENDIX AO

3D Parameters Table (Cont.) - Trilobal Elements

Configuration (α°)	Max Frontal Width on Main Problem	Active Variables in Main Problem	Static Variables in Main Problem	Swap Space Needed for Main Problem (MB)	Max Frontal Width on γ Problem	Active Variables in γ Problem	Static Variables in γ Problem	Swap Space Needed for γ Problem (MB)	Max Frontal Width on T Problem	Active Variables in T Problem	Static Variables in T Problem	Swap Space Needed for T Problem (MB)	Memory Size of Problem Directory (MB)
One Pair:													
0	767	12456	2084	78.6	333	5557	1870	24.8	598	7116	60	48.8	4.6
15	801	12451	2065	81.6	350	5500	1815	25.3	612	6984	48	49.0	4.7
30	699	12167	2031	71.7	286	5402	1815	23.2	472	6888	72	40.7	4.6
15 [1]	1441	35329	5539	358.4	578	14570	4225	62.8	984	17400	48	151.6	-
Two Pairs:													
0	1577	24128	4065	268.1	657	10546	3112	54.1	1144	12444	120	127.8	7.6
15	1937	27007	4494	363.9	761	11640	3334	65.6	1290	13572	96	154.1	8.2
30	1400	24212	4068	240.6	575	10523	3096	49.2	986	12360	144	111.4	10.2
Three Pairs:													
0	2381	36118	6100	586.8	972	15681	4404	102.7	1656	17964	180	250.6	13.3
15	3607	49415	8093	1207.4	1382	20670	5429	183.5	1866	19592	225	304.1	23.4
30	1968	36257	6105	489.7	784	15644	4377	85.7	1306	17832	216	199.1	13.2

NOTES:
1 Additional simulation performed as part of optimisation study.